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A
T R E A T I S E
O F
A R T I L L E R Y:

OR, OF THE
ARMS and MACHINES

Used in WAR since the
INVENTION of GUNPOWDER.

Being the FIRST PART of
LE BLOND'S ELEMENTS of WAR:

Written in *French* by that eminent Mathematician, for the Use
of *Lewis Charles of Lorraine, Count de Brionne*, and publish'd for
the Instruction of the young Gentlemen in the Armies of *France*.

Illustrated with, above FIFTY REPRESENTATIONS, beautifully engraved on
COPPER PLATES.

With REMARKS, and EXPLANATORY NOTES.

L O N D O N:

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MDCCXLVI.

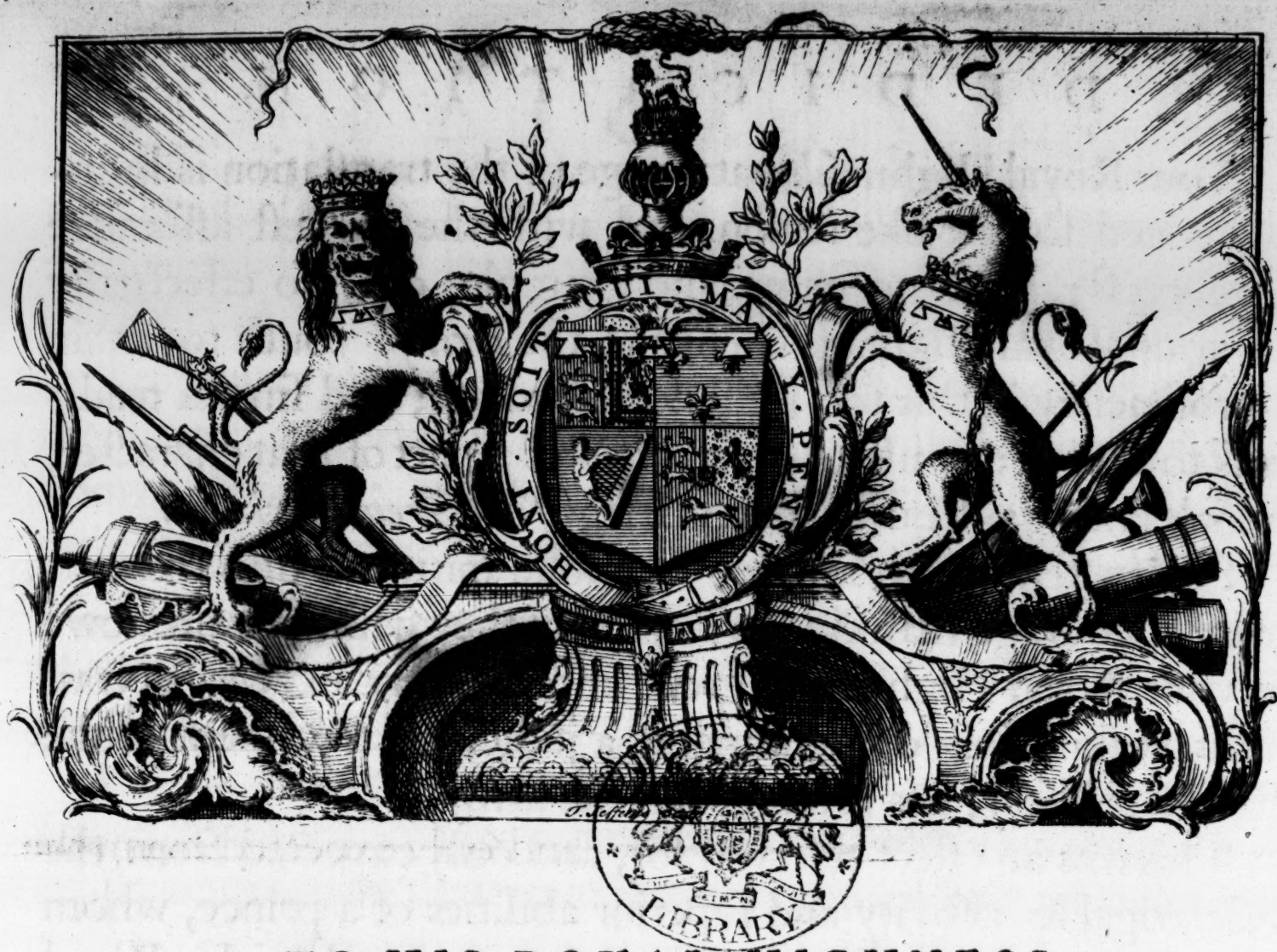
1746



WILLIAM D. CUMBERLAND

My dear Sir,
I have the honor to acknowledge the receipt of your letter of the 14th inst. in relation to the matter of the
which was obtained in France, where the same was
received with great enthusiasm, and
as translation into English.
The Commission was addressed to
the Court of Appeals, for
the purpose of obtaining a copy of the
which has been sent to the
in the name of the
of the
of the
of the





TO HIS ROYAL HIGHNESS

WILLIAM, Duke of Cumberland.

May it please your Royal Highness,



HE reputation which *Le Blond's Elements of War* obtained in *France*, where that science has receiv'd great encouragement, occasioned its translation into *English*.

The *French* edition was address'd to *Lewis Charles of Lorraine Count de Brionne*, for whose instruction in particular it was composed, that the influence of his name and example might lead the young gentlemen in the *French* armies to prosecute this study.

Your

D E D I C A T I O N.

Your Royal Highness's patronage of the translation is humbly hoped for the like reason, and with the highest assurance of success; since no name, no example, can, so effectually as your Royal Highness's, engage the *British* youth to attain a proficiency in this too long neglected art; and since a readiness to favour any useful design makes a part of that character, which endears You to every friend of *Great Britain*.

Such a testimony, at once of public spirit and discernment, must encourage mankind to hope, that they will some time owe to your Royal Highness as great improvement in arts, as your military skill, join'd to a humane, a judicious, treatment of the *British* soldiery, has produced in the army.

This was an effect reserved for, and only expected from, the indefatigable activity and superior abilities of a prince, whom the whole nation wished to see again appointed by his Royal Father, to repress the insolence of audacious rebels, aw'd only by his formidable name, and for which appointment it is now sending to his majesty, from every part of it, the warmest acknowledgments.

In these acknowledgments the tribute of praise, so singularly due to his Heroic Son, is not forgotten, tho', with a peculiar grace, your Royal Highness has been pleased modestly to attribute the easiness of the victory to the *guilt of the infatuated* rebels, and all the glory of it to "the resolution and firmness of your officers and soldiers."

And yet, Sir,---What other general could have animated fatigued troops, joyfully to bear a rigorous season, to pass with ardor bleak hills, unsound moors, craggy defiles, and rapid currents? What other general could have given *such resolution and firmness* to every individual of an army, as to stand,
unmoved,

D E D I C A T I O N.

unmoved, the impetuosity of a fierce desperate enemy, bold in imagined safety from the target, and superiority of the broadsword. What other general---But---

To repeat questions, which may insinuate defects in others, would certainly offend your Royal Highness's well known delicacy; and to attempt a further display of that military merit, which furnishes matter of conversation and surprise to all *Europe*, and calls forth the spontaneous thanks of every loyal subject thro'out the *British* dominions, would be a labour as needless as lighting up lamps to the sun.

For the whole world has now seen fully accomplish'd, what *Coningsleg*, the most experienced general of his age, predicted, when he observed that your Royal Highness had, in two campaigns, learnt more of the science of war, than many princes in ten. The conduct of that signal day of *Culloden*, has display'd the great commander which this sagacious chief foresaw in your Royal Highness's early attention to every incident in the field, and every exigence of the camp.

To enumerate your Royal Highness's social virtues, as a man, and as a prince, will be also unnecessary; as unnecessary as difficult! because that compassion, bounty, condescension, sweetness of temper, and engaging affability, which distinguish your Royal Highness, abundantly appear in their happy effects,---an universal esteem and veneration.

And it would be the highest presumption, for a private person, to hope to raise any mark of honour to the character of a Prince, who has received the unanimous thanks of the two most august assemblies in the universe, the Lords and Commons of *Great Britain*, the most public and most solemn attestation of your Royal Highness's exalted worth, as well as of the affection

D E D I C A T I O N.

affection and gratitude of a joyful nation, snatch'd, by your victorious hand, from the worst of miseries, slavery and superstition.

I cannot conclude, altho' more than once comprehended in representative addresses, without professing my particular obligation to your Royal Highness for the protection of one great branch of the freedom of our constitution; the freedom, by which these sheets appear without a badge of slavery, the invaluable freedom of the press.---Separate communities, the universities, the clergy, cities and corporations, have signify'd a transporting joy on account of their respective privileges delivered from violation by your Royal Highness's admirable courage and conduct, without once noticing, that the press, which promulgates all their congratulations, is preserved from a licenser. But that your Royal Highness hazarded your precious life also in defence of this general privilege, shall ever be remember'd. This act the press shall record to latest posterity, with innumerable compositions, to celebrate the illustrious instrument of her security: For the press, while free, will ever co-operate, as it has remarkably done in this cause, with the sword, against all lawless power, against all indefeasible hereditary claims to tyranny, and in the support of liberty, and the present happy establishment.

I am, under the greatest ties,

May it please your Royal Highness,

Your Royal Highness's

Most obedient, most humble servant,

The EDITOR.

Advertisement.

THOUGH M. LE BLOND calls his work *The Elements of War with respect to Sieges*, it comprehends most things necessary for the camp in general. He has disposed it in three parts: The FIRST (*Of Artillery, or the arms and machines used in war since the invention of gunpowder*) explains the composition, properties and use of gunpowder; gives the different sizes, figures, carriages, charges, of cannon, mortars, and pedreros; with the method of pointing, proving, and managing them; shews the art of making and throwing bombs, carcasses, cartouches, and grenadoes; the manner of nailing up cannon, and how to remedy the widening of the touch-hole; establishes rules for the construction of batteries, mines and counter-mines, pontons and bridges, and of all those engines and fireworks which are used in the *Attack and Defence* of fortify'd places; to which are added estimates of the cannon, carriages, and other implements necessary for an army, also of the quantities of stores of all sorts, and the provisions, to be collected preparatory to a siege. Such are, in short, the contents of his first and introductory volume, the part herewith published, which may either be put into covers by itself, or be bound up with the two other parts in one volume in 4to.

His second volume treats of the *Attack*, and his third of the *Defence* of *Fortified places*, and both convey that useful knowledge in those branches of this art, which cannot be neglected by such gentlemen as have undertaken, or may be called, to serve their country in a military capacity.

To render his work more agreeable, and of general service, M. *Le Blond* has carefully avoided, as much as possible, technical terms, and Geometry, that, instead of deterring the youth of *France* from the study of so important a science, he might, by removing all difficulty, engage and excite them to it, and induce them, by the facility of the means, to gain a superior knowledge in all the parts of the *grand art of war*.—

This is the substance of *Le Blond's* prefatory advertisement. His Dedication to the Count *de Brionne* informs us, that the rules contained in these his treatises are the same which he taught to that young nobleman, whose example, in making the art of war his study, he hoped, would have a proper influence.

It

It is not necessary to say any thing further with regard to the character of this work, than that it is well received in *France*, where the subject is generally thought to be very well understood. We hope, however, to have given it to our countrymen with some degree of improvement, by inserting remarks even from *English* writers, by subjoining some military figures from other authors, and by enlarging the dictionary of the terms.

What we have added in the course of the work, will be seen by the references being different from those to the author's own notes, which have the numbers, 1, 2, 3, &c. prefixed, and what we shall add in the conclusion will appear by way of supplement.

The subject of these sheets is so far from being foreign to any state or profession, since what has so lately happened in the heart of *England*, and what has been and is still threatened on its coasts, that it were to be wished every man of property in the kingdom was thoroughly qualified to defend it.---And with regard to the young gentlemen of the army, and train of artillery, who have made diligent enquiries for useful books of this sort, 'tis hoped that *Le Blond* speaking our own language will afford them such hints (the known talent of the *English* being to improve) that a *French* engineer will no longer be named with any degree of preference.

E R R A T A.

Page 8, line last of the note, read superficies. p. 10, note, col. 2, l. 5, 6, r. by this rule then the weights of bullets may be found whose diameters are given. p. 11, l. 23. for Moyenne, r. Mion. p. 13, l. 1, r. of. l. last for avaut r. avant. p. 28, l. 10, after this, dele comma. p. 31, l. 4, r. fine. p. 34, l. 11, r. contained. p. 62, l. 18, r. is.

T H E C O N T E N T S.



Chap. I. <i>O</i> F gunpowder	page 1
Sect. 1. <i>Of the composition and method of making gun-</i> <i>powder</i>	2
2. <i>Of the time when powder was invented</i>	4
Chap. II. Sect. 1. <i>Of cannon</i>	6
2. <i>Of the composition of the metal of cannon</i>	9
3. <i>Of the different kinds of cannon</i>	ib
4. <i>Of the thickness and length of the principal parts of cannon</i>	12
5. <i>Of the carriages of cannon</i>	13
6. <i>Of the manner of charging cannon, and the instruments necessary</i> <i>for that purpose</i>	14
7. <i>Of the manner of powder's taking fire</i>	16
8. <i>Of the invention of spherical chambers, the reason why they are</i> <i>disused, and of the shape of the interior part or bore of cannon</i>	17
9. <i>Of the manner of pointing cannon</i>	20
10. <i>Of the different ranges of cannon</i>	21
11. <i>Of the ricochet, or rolling and bounding shot</i>	23
12. <i>Of the quantity of powder necessary for the charging cannon</i>	ib
13. <i>Of the manner of determining the length of cannon, with respect</i> <i>to a given charge of powder; or rather when the length of the</i> <i>piece is given, how to find the quantity of powder proper to give</i> <i>the bullet its greatest possible force</i>	25
14. <i>Of the use of the wad, with which the powder in a piece is cover'd</i>	27
15. <i>Of the number of times the same cannon may be fired successively</i>	28
16. <i>Of</i>	

The CONTENTS.

16. Of the method to remedy the widening of the touch-hole, or, which is the same thing, to put in a new piece of metal	29
17. Of the manner of nailing up cannon, or stopping the touch-hole, so as to render the piece unserviceable	31
18. Of red-hot bullets	33
19. Of gargouges and cartouches	ib
Chap. III. Sect. 1. Of the mortar	36
Sect. 2. Of the carriage of the mortar	37
3. Of the position of a mortar proper for firing a bomb, and the line described by a bomb during its motion	39
4. Of the method to be used, in order to throw a bomb upon a place proposed	40
5. Remark on the foregoing method of throwing bombs	44
6. Of the different kinds of mortars	45
7. Remark upon the chambers of mortars	48
8. Of bombs, and the quantity of powder with which they ought to be charged	ib
9. Of the fuses of bombs	50
10. Of the instruments necessary to charge mortars, and of the manner of charging them	51
11. Remark on the same	52
12. Of the manner of levelling, or pointing a mortar, or giving it a proper degree of inclination	ib
13. Of bombs fired by way of the ricochet	53
Chap. IV. Sect. 1. Of pedreros, or mortars for discharging of stones	56
Sect. 2. Of the carriage of the pedrero	57
3. Of the manner of charging the pedrero	ib
Chap. V. Of grenadoes	58

Chap.

The CONTENTS.

Chap. VI. Sect. 1. <i>Of carcasses</i>	59
Sect. 2. <i>Of partridge mortars, for firing bombs and grenades together</i>	60
Chap. VII. <i>Of the Obus</i>	61
VIII. <i>Of the Arquebuse a croc</i>	ib
IX. <i>Of the carabine</i>	62
X. <i>Of the petard</i>	63
XI. Sect. 1. <i>Of batteries and their construction</i>	66
Sect. 2. <i>Of batteries of mortars</i>	69
3. <i>Of different kinds of batteries</i>	70
Chap. XII. Sect. 1. <i>Of mines</i>	71
Sect. 2. <i>A description of mines, and their use</i>	ib
3. <i>Observations and principles for the calculation of mines</i>	72
<i>A Table for the charging of mines ; calculated by M. de Valliere, Lieutenant-General of the King's armies, and Inspector-General of the schools of artillery</i>	79
4. <i>New observations and experiments for perfecting the calculation of mines</i>	81
5. <i>Of the construction of mines and their galleries</i>	88
6. <i>Of the different kinds of mines</i>	93
Chap. XIII. <i>Of the fireworks most used in the attack and defence of places</i>	97
	Chap.

The CONTENTS.

Chap. XIV. <i>Of bridges</i>	101
XV. <i>Of the proof of powder</i>	104
XVI. <i>Of the proof of cannon</i>	105
XVII. <i>Of the proof of mortars</i>	109
XVIII. <i>Of the artillery necessary for an army</i>	110
<i>A table of things necessary for a train of artillery consisting of fifty pieces of cannon</i>	111
XIX. <i>Of the march of a train of artillery</i>	121
XX. <i>Of the artillery-park</i>	122
XXI. <i>Of the ammunition necessary for forming the attack or siege of a fortified place</i>	124
<i>List of the ammunition and provisions collected together for the siege of ****</i>	152
<i>Of ammunition carried to the siege of Turin, and of what was there consumed</i>	



A TREATISE OF ARTILLERY.

CHAP. I. *Of GUNPOWDER.*



BEFORE we describe the works necessary for the taking a fortified town, or treat of the manner of its defence, it is proper to give an account of the arms or machines necessary for such undertakings, and the manner of using them, which is the subject of this treatise.

*Of Gun-
powder.*

B

SECT.

SECT. I. *Of the composition and method of making Gunpowder.*

WE shall begin with a brief description of gunpowder, which is now the soul of almost all military machines. It is compounded of three 4ths of saltpetre, one 8th of sulphur, and one 8th of charcoal; so that in 100 pound of powder there are 75 of saltpetre, 12 and a half of sulphur, and as much charcoal. †

These three ingredients must be beaten together in a mortar for about 24 hours, then taken out and put into a sieve with two or three bottoms or grates of copper; the holes of which are not directly under each other, and are less in the under than the upper grate. In passing through these holes the composition is formed into grains, || and it is forced through them by means of a small wooden cylinder, 9 or 10 inches long, and 1 inch and a half thick, called a roller, which turns round on the powder in the first bottom as the sieve is moved backward and forward upon the sticks or rails that support it; the powder being, by the weight of this roller, forced in large grains to the second bottom, in which the holes are less, it is forced through these by frequent striking the sieve against some-

† The standard of the gunpowder made for the use of the government in England is, to a barrel of powder of 100 pound neat weight, 80 pound of refined saltpetre, 16 pound of charcoal dust, and 14 pound of sulphur; the surplus weight in the composition, which is 10 pounds, is to answer the waste in making.

|| Gunpowder, for some time after the invention of artillery, was not only much weaker, but used in the form of fine meal, to which it was reduced by grinding the materials together; and the invention of graining it is doubtless a considerable advantage; for it acquires great ad-

ditional strength from the free passage of the fire between the grains. And yet it is uncertain whether the first grinding of powder was intended to increase its strength, or only to render it more convenient for filling into small charges, and charging small arms; the latter is the more probable, because the grain-powder was for a considerable time applied only to that purpose, and the meal-powder continued to be used with cannon; the additional strength of the grain-powder seems therefore to have been found out by experience, when the other was entirely disused.



ARTILLERY.

3

something solid; * the powder being thus made is dry'd, and lightly put into barrels, which contain 200 pounds, and these barrels are put into others for further security.

The saltpetre is that part of the composition which gives it sound and strength, † the sulphur serves to kindle it with the greater ease; but as its flame is very thin, and of short duration, the charcoal serves to give it a longer subsistence, and so prevents the violent force or blast of that part of the saltpetre which is first lighted from extinguishing this flame before the whole has taken fire ‡.

B 2

Char-

* Our method of making powder, as related by *Chambers*, is as follows.---All the ingredients are first to be finely powdered, then moistened with fair water, or vinegar, or spirit of wine, or with water and spirit of wine mixed together, or urine, which is usual; afterwards all must be well beat for the space of 24 hours at least, and then granulated after the following manner; a sieve is to be prepared with a bottom of thick parchment made full of round holes, and the former beaten mass moistened before-hand with twenty ounces of spirit of wine, twelve of spirit of wine vinegar, thirteen of spirit of nitre, two of spirit of sal armoniac, and one ounce of camphire dissolved in spirit of wine: and let all these be mingled together. Otherwise take 40 ounces of brandy, and one of camphire, and let them be mixed and dissolved for the said purpose: when the whole compound is made up into balls as big as eggs, put them into the sieve, and with them a wooden ball, which move up and down about the sieve, so that it may break the balls of powder, and make it pass through the little holes in corns.

† The distinguishing property of saltpetre is the prodigious increase of inflammability, which it produces in all burning substances, when mixed with them, although alone it will neither flame nor burn; for if put into a crucible and pla-

ced in the hottest fire, it will only melt, or grow red-hot, without producing any explosion or flame; yet if any inflammable substance be thrown upon it, as sulphur or coals, a violent flame will be instantly produced, in which a part of the saltpetre will be consumed in proportion to the quantity of the inflammable substance which was put to it; and a like explosion will take place, if the saltpetre be thrown on any fire.

‡ This seems to be but an imperfect account of the intention and use of the several ingredients in this great composition; for the quality of saltpetre, mentioned in the above note, being observed, it was a very natural and obvious thought to mix it with such inflammatory substances, as would burn more violently than any known before. Sulphur was very likely to answer this end; but it was necessary that the composition should take fire easily, and kindle from a spark. To produce this effect, charcoal seems to have been added; that it actually does answer this end is evident, for a flint and steel would never kindle pulverized sulphur or saltpetre, either separate or mixt, but will presently light charcoal, if ground to a fine powder; from whence it appears that charcoal is the tinder, brimstone the match, and both together the body of that composition, of which saltpetre is the soul.

Charcoal is not absolutely essential to gunpowder; burnt linen may be made use of in its stead, or the pith of elder well dried; but charcoal is preferred, because it is very common, and easily prepared.

There are two sorts of powder; the first, called cannon-powder, is what is commonly used in an army; the second, called fine powder, is that commonly used in fowling. The grains of the cannon-powder are larger than those of the fine, which is also called fowling-powder. There is yet another sort of powder called priming-powder, which is only the ordinary powder bruised, to render it finer.

This is the composition of gunpowder, the effects of which are so astonishing, and which has produced so many alterations in the fortifications and arms which were antiently used in war.

SECT. II. *Of the Time when Powder was invented.*

IT is very difficult to fix the exact period of time in which gunpowder was invented in *Europe*; I say in *Europe*, because many authors pretend it was used long before in *China*. The most common opinion is, that it was discovered about the year 1330, by a *German* monk named *Bertholdus Schwartz*, || or *the Black*, who used to divert himself with chymistry. This monk having put a composition of sulphur and saltpetre in a mortar, it took fire, and threw off a stone that covered it with great violence; which effect induced the chym-

|| It is certain that a composition, much like what we now call *powder*, is mentioned by our countryman *Roger Bacon*, as well known in his time; and he lived 56 years before *Schwartz*. *Marcus Græcus* also, in a treatise intitled *Liber ignium*, prescribes a composition for fireworks, of

two pounds of charcoal, one pound of sulphur, and six pounds of saltpetre; a composition much stronger than many sorts of powder now made. See Doctor *Jebb's* preface to his edition of *Bacon's Opus majus*.

chymist to think it might be used with great advantage in the attack of fortified places. He accordingly apply'd himself with great diligence to bring it to perfection, and added to it a quantity of charcoal, to render it more apt to take fire, and to continue it.

* There is great uncertainty as to the time when this discovery of *Schwartz* was first brought into use; some authors affirm that, in 1366, the *Venetians* besieging a town then called *Fosse Caudiane*, and now *Chioggia* (which had been taken from them by the *Genoese*) some *Germans* brought them two small pieces of artillery, with some gunpowder, and leaden bullets, the use of which rendered the reduction of the place much more easy and expeditious.

But others carry the use of gunpowder further back; according to *Du Cange* and father *Daniel*, it appears, by the registers of the chamber † of accounts, that in the year 1338 cannon-powder was made use of in *France*. But be this as it may, we find from the greater part of historians, that the use of it was not established till the long wars between *Francis* the 1st and *Charles* the 5th. From the first invention of powder to this period, both the machines in use before that discovery, and those which that discovery introduced, were used in war at the same time; and even some time after this period both sorts of machines were continued in use. But those which ow'd their rise to the invention of powder have now totally superseded the others, and there is scarce any but the sword remaining of all the weapons of the ancients.

Whether

* Tho' *Schwartz* was not the first inventor of powder, he might probably be the first that apply'd it to military affairs. And this account of the manner of his acquiring the knowledge of its composition and effect, and the figure and name of *mortars* given to a species of the first artillery, and the use made of them

which was to throw great stones at an elevation, much favour this opinion.

† The chamber of accounts is a sovereign court, where accounts are rendered of all the king's revenues, inventories, and vouchers thereof registered, and other matters relating to the finances transacted.

Whether powder, which was at first esteemed the most pernicious and destructive invention that the wit of man ever produced, has really been the cause of so much evil as is generally imagined, is a question easily decided, if we consider the remark of Mr *Fontenelle*, “* that whatever renders war more short and decisive renders it less destructive and fatal, and that a much greater number must perish during the long sieges related in antient authors, than in those of the present day, which are beyond comparison more short.”

* *Histoire de l'Academie des Sciences*, ann. 1707.



C H A P. II. SECT. I.
Of CANNON.

ALL the machines used with gunpowder were at first called *cannon*, or *bombards*; † but this custom has long since been changed. That which is now called a *cannon*, is a fire-arm of brass or iron, long and round, concave within, and thicker at the end opposite to its opening than at the opening, which is called its mouth.

Its principal parts are,

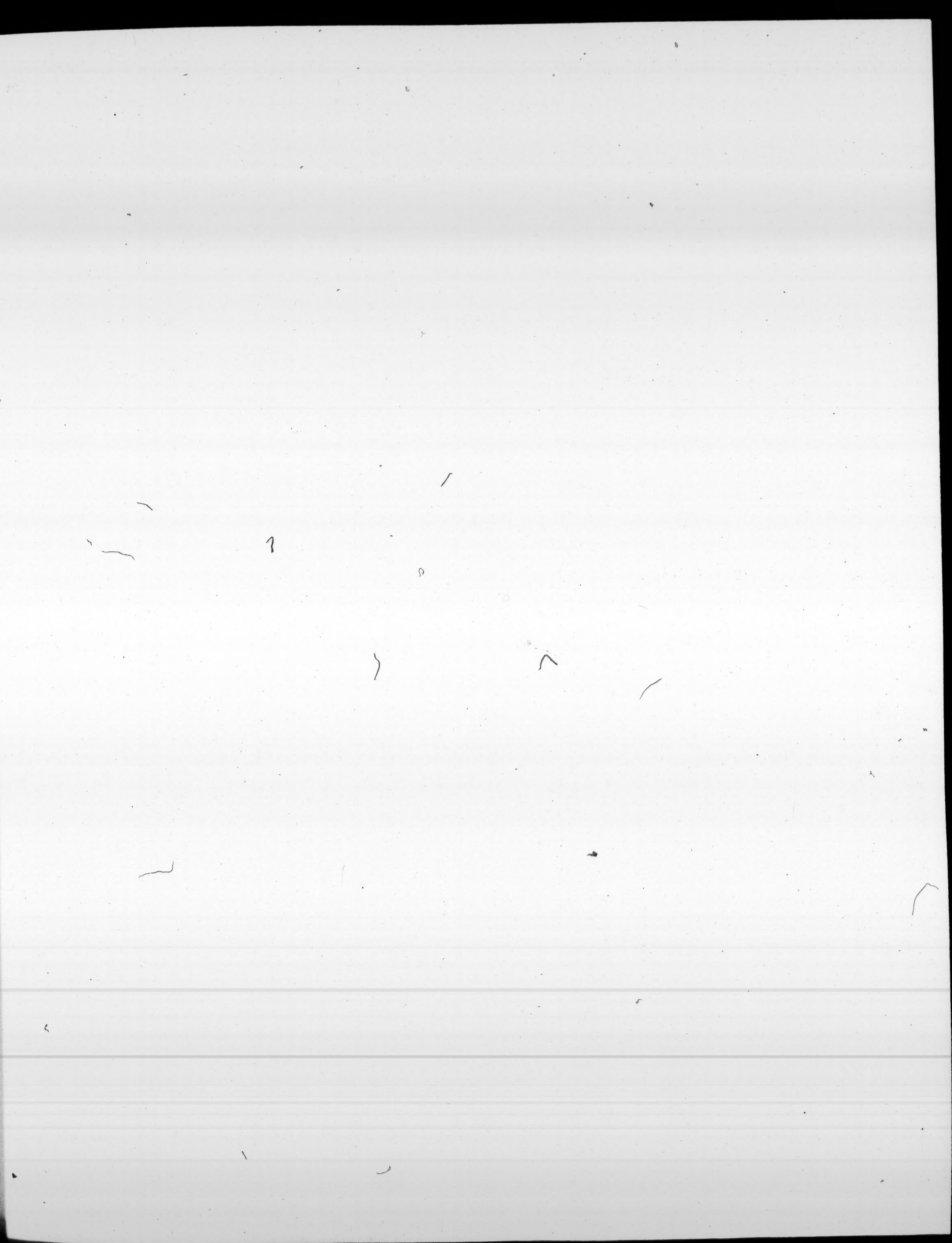
PLATE
I.
Fig. 1.

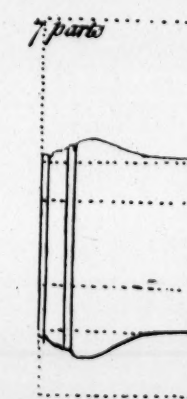
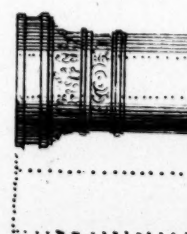
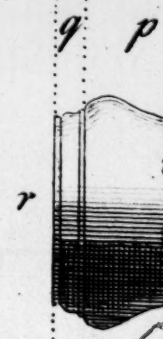
1st, The breech *a*, and its button, or cascabel; the breech is the solid metal from the bottom of the concave part to the cascabel, which is the extremity of the cannon opposite to its mouth.

2^d, The

† The first pieces of artillery were of a very clumsy, inconvenient make, being usually framed of several pieces of iron, fitted together lengthwise, and then hooped with iron rings; and as they were used for throwing stones of a prodigious weight, in imitation of the ancient machines, to which they suc-

ceeded, they were of an enormous bore. But the difficulty of conducting and managing these pieces, and the discovery that iron bullets of much less weight, impelled by better powder, were more efficacious, soon introduced the present fabric and matter of cannon.







a Twenty four Pounder

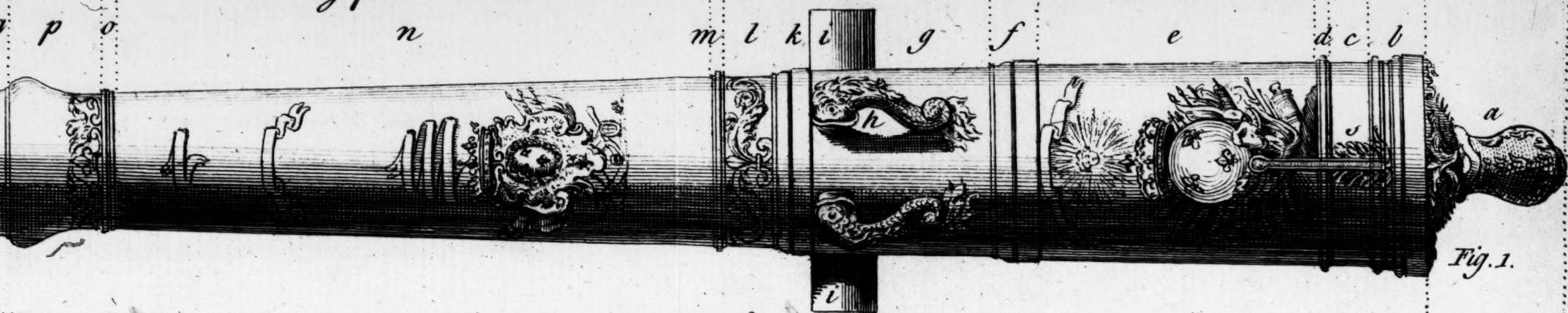


Fig. 1.

10 Feet 1 Inch 11 Lines

12 Feet 11 Lines

Culverine of Nancy

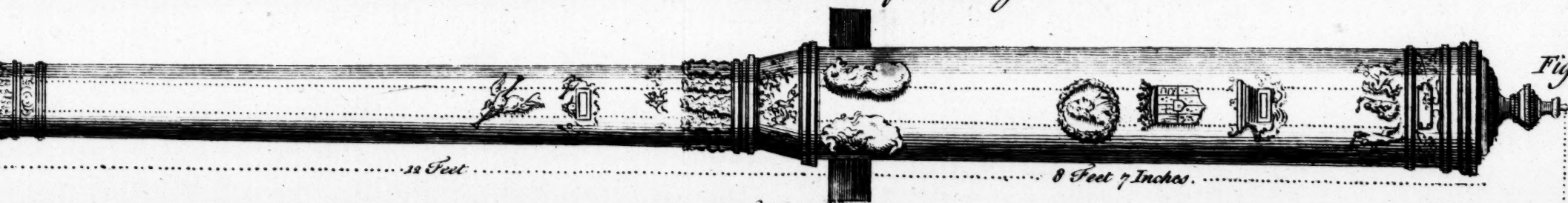


Fig. 2.

12 Feet

8 Feet 7 Inches

21 Feet 11 Inches 6 Lines

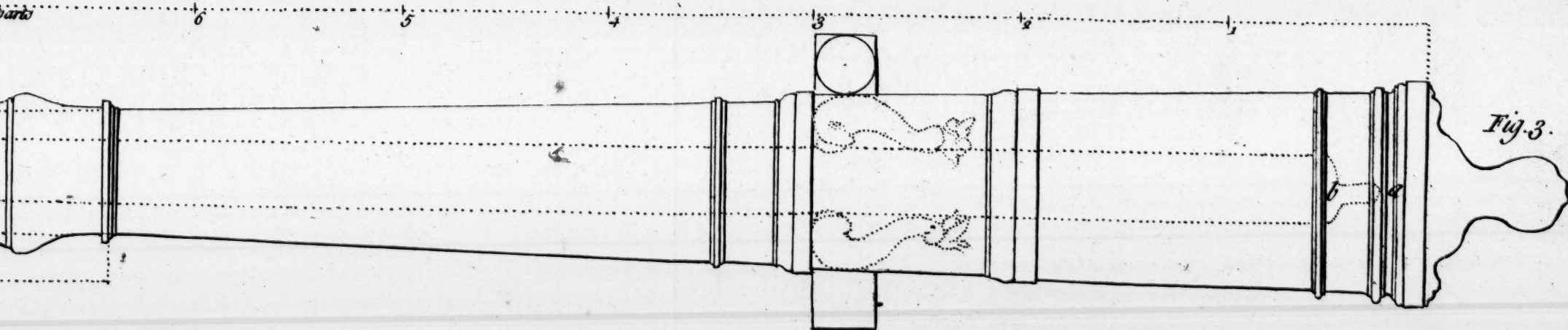
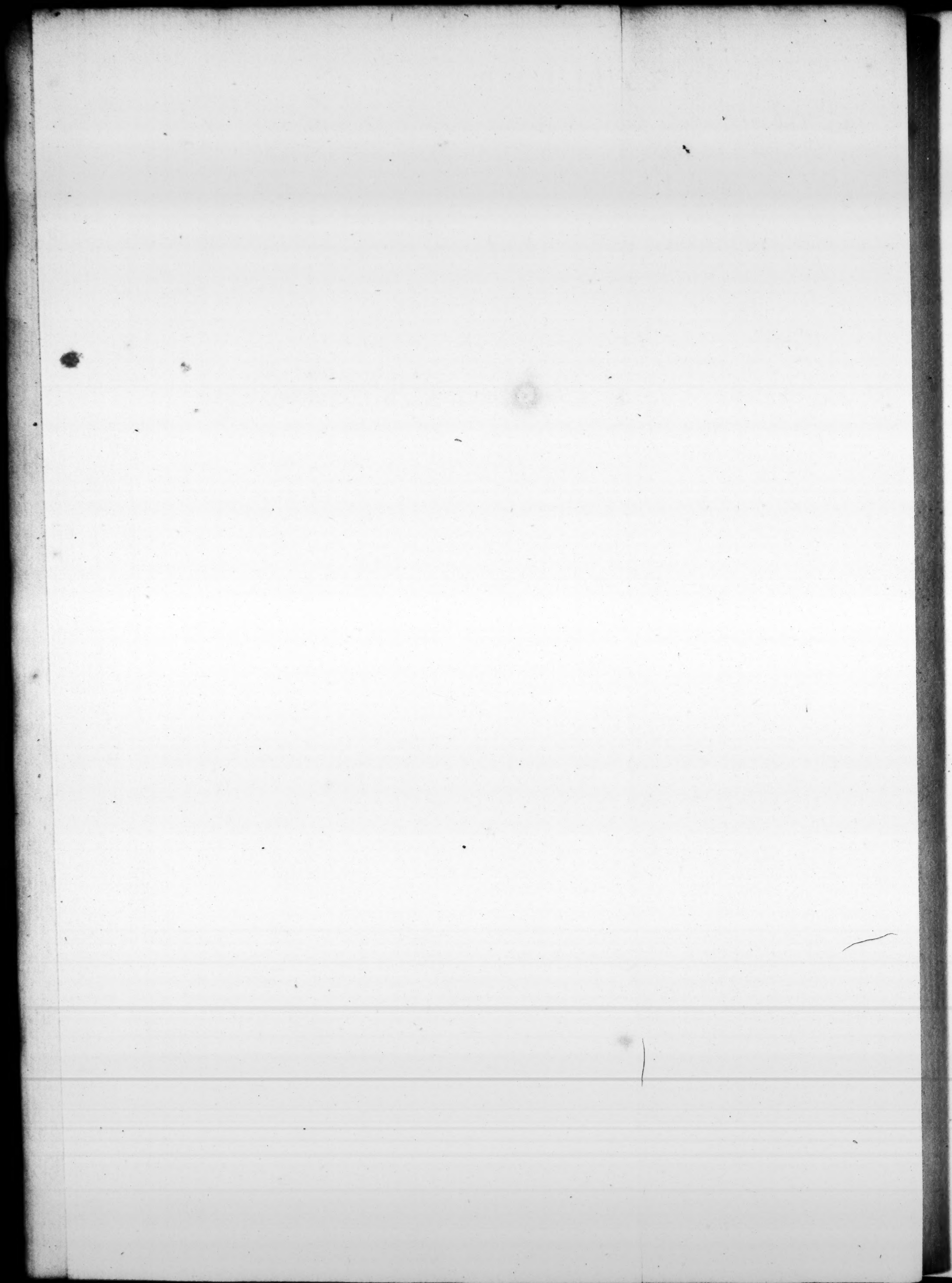


Fig. 3.



2d, The trunnions *i* stand out on each side like an arm, and serve to support the cannon; on these it may be poised, and held almost *in equilibrio*; I say almost, because the breech-end ought to be about the 30th part of the weight of the piece heavier than the other; as the metal is thicker at the breech than towards the mouth, the trunnions are placed nearer to that end than the other.

3d, The bore, or chace, which is all the interior or concave part of the cannon; this is mark'd, in *Fig. 3*, by two prick'd lines.

4th, The touch-hole *f*, which is an aperture made near the breech, thro' the whole thickness of the metal, by which the powder is fired that lies within the cannon. This hole is made in a small cavity resembling the inside of a scallop-shell, sunk for that purpose in the upper part of the piece.

5th, The ears, or handles, *h*, (called by us *Maniglions*, or *Dolphins*,) are two rings, of the same metal with the piece, placed as the trunnions, only something nearer the breech, made in the shape of dolphins, serpents, &c. Through these is put a rope to raise or move, mount or dismount, the cannon, which suspended on these handles ought to be *in equilibrio*, that is, the breech ought not to be heavier than the mouth.

* *Names of other parts of the Cannon.*

b The platband and moulding of the breech.

c The region of the touch-hole.

d The

* The several parts of our cannon are named as follows, in *Harris's Lexicon*.

1. " The outside, round about the piece, is called the *superficies of her metal*.

2d, " The substance, or whole mass of metal, is called the *body*.

3d, " The part next to us, when it stands ready to fire, is called the *breech*, or *coyle*, and the pommel, or

" round knob, at the end of it, is called the *Cascabel*; by some the *Cascabel dock*.

4. " *Trunnions* are the two knobs, spindles, or ears, which hold the piece in the carriage.

5. " *Maniglions*, or *Dolphins*, after the German way of casting guns, are two handles placed on the back of the piece near the *Trunnions*, and near
" the

d The astragal of the touch-hole.

e The first renfort.

f The platband and moulding of the first renfort.

g The second renfort.

k The platband and moulding of the second renfort.

l The cincture or ornament of the chace.

m The astragal of the cincture.

n The chace.

o The neck astragal.

p The neck with the border in tulip-work. [peculiar to the *French*]

q The crown with its mouldings.

r The mouth.

These cannon discharge, by means of gunpowder, globes or balls of iron, called *bullets*.

S E C T.

“ the centre of gravity, to mount
“ and dismount it the more easily.

6. “ The *rings* about it are these
“ four: The *base ring* is that which is
“ next below the touch-hole: The
“ next ring above the touch-hole is cal-
“ led the *reinforced ring*: The next to
“ that, forward, the *Trunnion-ring*: The
“ next to that the *Cornice-ring*: And
“ that at the mouth is called the *muzzle-*
“ *ring*, or the *Freeze*: Also all the
“ rings near the mouth are sometimes
“ called the *Freezes*.

7. “ As to the internal parts, the
“ whole cavity or *bore* of the piece is
“ called her *chace*. That part of the ca-
“ vity between the *trunnions* and the
“ *muzzle* or mouth, is called the *vacant*
“ *cylinder*: The part from the *trun-*
“ *nions* to the end of the cavity, or so
“ much of it as containeth (or is *load-*
“ *ed with*) the powder and shot, is cal-
“ led the *chamber*. The diameter of
“ the mouth is called the *calibre*. The
“ space between the shot and the hollow
“ superficies of the piece within, is called

“ the *vent*; being the difference between
“ the diameter of the shot, and of the
“ mouth of the piece.”

*The several Parts of a Gun, as now
named by our own Artillery People.*

1. The cascabel.
2. The cascabel astragal.
3. The neck of the cascabel.
4. The breech and breech mouldings.
5. The base-ring and resistance.
6. The vent and vent-astragal.
7. The charging cylinder.
8. The first reinforced ring.
9. The first reinforced astragal.
10. The vacant cylinder.
11. The dolphins.
12. The trunnions.
13. The second reinforced ring.
14. The second reinforced astragal.
15. The chace.
16. The neck astragal.
17. The neck and muzzle ring.
18. The muzzle mouldings or freeze.
19. The face of the piece.
20. The bore or concavity.

SECT. II. *Of the Composition of the Metal of Cannon.*

THE metal of which cannon are made, is a compound of copper, brass, and tin. The respective quantities of each of these, which should enter into this composition, is a point not decided; every founder has his own proportions, which are peculiar to himself, but the common proportion of these ingredients to a quantity of metal, is one third of copper, one fourth of brass, and one seventeenth of tin; for example, to 204 pounds of metal fit for casting, they put 68 pounds of copper, 52 pounds of brass, and 12 pounds of tin.

With respect to iron cannon, their structure is the same with the other; they are not however capable of the same resistance as those of brass, but they cost much less; these are commonly used on shipboard, and on some occasions on shore.

SECT. III. *Of the different Kinds of Cannon.*

CANNON are of different sizes, in proportion to which they discharge bullets of more or less weight.

Cannon were formerly made to carry a 33 pound, a 48 pound, and even a 96 pound bullet; and M. *Saint Remy* observes, in his *Memoirs*, that there is still one of this last sort in the city of *Strasbourg*; but the largest cannon now commonly cast are those which carry a bullet of 24 pounds weight, and which are therefore called *twenty four pounders*.

Cannon generally take their names from the weight of the bullet which they discharge; thus a piece that discharges a bullet of

C

of

A TREATISE of

of 24 pounds, is called a *four and twenty pounder*, one that carries a bullet of 16 pounds, is called a *sixteen pounder*, and so of the others.

Cannon are also distinguished by the diameter of the mouth, or bore, which is generally called the caliber of the piece; so if this diameter is three, four inches, &c. the cannon is said to be a piece of three, four, &c. inches caliber.

The diameter of the bullet, or ball, ought to be about two lines (or two 12ths of an inch) at least less than the bore of the piece, that it may be discharged with the greater ease, and not damage the piece by rubbing it too forcibly in its passage; this is called the *vent* of the bullet.

When the diameter of a bullet and its weight are known, it is easy to find the weight of all bullets having the diameter given, and the diameter of all bullets, if the weight be given. Geometry has furnished certain rules for effecting this (1) which are mention'd among the uses of the sector.

The

(1) It is demonstrated in the elements of geometry, that similar solids are to each other as the cubes of their homologous, or correspondent, sides or diameters; bullets are similar solids, and therefore they are to one another as the cubes of their diameters. If we suppose the weight and diameter of a bullet to be known by experiment, for example, if it is found that a bullet of four pounds weight is three inches in diameter, the weight of any bullet may be easily found, if its diameter be given, and the diameter of any bullet, if the weight be given.

Let it be supposed, for instance, that the weight of a bullet of five inches diameter is required, this will be found by the rule of three, by saying, As the cube of 3, which is 27, is to the cube of 5, which is 125, so is 4 pounds to the 4th

term, or the weight required; or $27 : 125 :: 4 : \text{the fourth term}$, which will appear to be 18 pounds and an half, the weight of a bullet 5 inches diameter; by the same rule the weight of bullets may be found whose diameter are given.

But now supposing the weight of a bullet to be given, and its diameter required, this will be found by saying, As the weight of the first bullet (that is, the bullet whose weight and diameter have been found by experiment) is to the weight of the bullet given, the same is the cube of the diameter of the first, to the cube of the diameter of the second; the fourth term of the rule of three will then give the cube of the diameter required, from which extracting the cube root, the diameter sought will appear.

The 24 pounders are used in sieges, to batter and destroy fortifications; their length is 11 feet, including the length of the cascabel; and their weight ought to be (according to an ordinance of the 7th of *October* 1732) 5400 pounds or upwards; their bore is about five inches eight lines, and consequently the bullets they carry are about five inches six lines diameter.

Besides these pieces of 24 pounders, there are others, *viz.* 16, 12, 8, and 4 pounders.

The 16 pounders are called *demi-cannon*, or *culverins*; their bore is 4 inches 11 lines, they carry balls of 4 inches 9 lines diameter; their length is about 10 feet 6 inches, and their weight 4200 pound at most; there are some longer, and, among others, the piece called *the Culverin of Nancy*, from its having been cast in that city. For the figure of it see *Plate I, Fig. 2.* it carries a ball of 18 pounds.

PL. I.
Fig. 2.

It is now common to call any piece a *Culverin*, which is longer than other pieces of the same bore.

The twelve pounder carries bullets of 4 inches 3 lines diameter, its length is about 10 feet, and its weight 3200 pound at most.

The eight pounder is called a *bastard* or *demi-cannon*; its length is about 8 feet 10 inches, its weight ought to be 2100 pound at most, it carries a ball of about 3 inches 10 lines diameter.

The four pounder, *Moyenne*, or middle size, ought to be 7 feet 3 inches in length, its bore is about 3 inches 2 lines, and by consequence the bullet it carries is no more than 3 inches diameter; the weight of this piece ought to be 1150 pound.

Besides these pieces, there are others still less, that carry from two pounds to a quarter of a pound of ball; these are called falcons, their length is about 7 feet, and their weight varies from 800 down to 150 pounds.

SECT. IV. *Of the Thickness and Length of the principal Parts of Cannon.*

THE metal of cannon is not equally thick in all parts, but is in some measure proportioned to the force of the powder which it is to resist ; at the breech, where the effort is strongest, the thickness of the metal is equal to the diameter of the bullet of the piece ; at the first renfort, where the force begins to diminish, the thickness is somewhat less than at the breech ; at the second, where the force is further diminished, the thickness is less than at the first; and by the same rule the chace has less thickness than the second renfort. The thickness of the chace gradually diminishes from the trunnions to the mouth of the piece. If a cannon was without cascabel, or button, trunnions, and mouldings, it would exactly resemble the frustum of a cone, or a cone the small end being cut off.

If the diameter of the ball be divided into 12 equal parts, the thickness of the metal at the breech of the piece will be equal to the whole 12 ; to eleven at the end of the first renfort, nine and an half at the end of the second, seven and an half at the neck astragal, the same at the extremity of the chace ; and at the greatest protuberance of the border, or moulding at the muzzle, eight and an half.

With respect to the length of the piece, if it is divided into seven equal parts ; from the extremity of the platband of the breech, to the extremity of the mouth, the first renfort will be two of these parts ; the second renfort will terminate at the end of the third part, which is also the place of the trunnions; and the four remaining parts will be the length of the chace.

The length and thickness of each trunnion are equal to the diameter of
of

of the piece, and the length of the cascabel is two diameters of the bullet.

All these proportions have been established by experience, which has shewn, that cannon in which they were nearly observed have been capable of doing good service; I say nearly, because they are not kept with a geometrical exactness. The ordinance of the 7th of October 1732, obliges all founders to follow these proportions.

SECT. V. *Of the Carriages of Cannon.*

CANNON are placed on a sort of cart, or dray, which is called the *carriage*. (See *Plate II. Fig. 1.*) This carriage is composed of two long pieces of wood, called *sides*, or *cheeks*, which are made in a bending form, so that (*Plate II. Fig. 2.*) one end of them *b* rests on the ground, and the other *a* is supported by the axis or axle-tree of the wheels, from which it jets out about a foot. The cheeks are join'd to each other by four pieces of wood, called cross-quarters or transoms; the first *a* is called the transom of the chace; the second *c* the transom of the bed; the third *d* the transom of the fight; and the fourth *g*, which fills all the space between those parts of the cheeks that rest on the ground, is called the transom of the lunet, or eye-hole. In the cheeks, between the part that is opposite to the transom of the chace, and that which is opposite to the axle-tree of the wheels of the carriage, are two semicircular notches, in which the trunnions of the cannon are placed; on the three first transoms *a c d* is placed a piece of wood of a proper thickness, on which the breech of the cannon rests; this plank is called the *bed* of the carriage.

PL. II.
Fig. 1.

Fig. 2.

When the cannon is to be carried into the field, or removed from one place to another, the limber (avaunt-train) or fore-carriage, is added

PL. III.
Fig. 1, 2.

added to that part of the cheeks where the transom of the *Lunette* is placed. See *Plate III. Fig. 1.*—And for the plan of the fore part or limber, and the carriage to which it is fixed, see *Plate III. Fig. 2.* *

Besides the carriage now described, which is the most common, and called the *wheel-carriage*, there are fort-carriages, sea-carriages, and bastard-carriages, which have low solid wheels, that serve to move them on a rampart, or to and fro in other places of small extent.

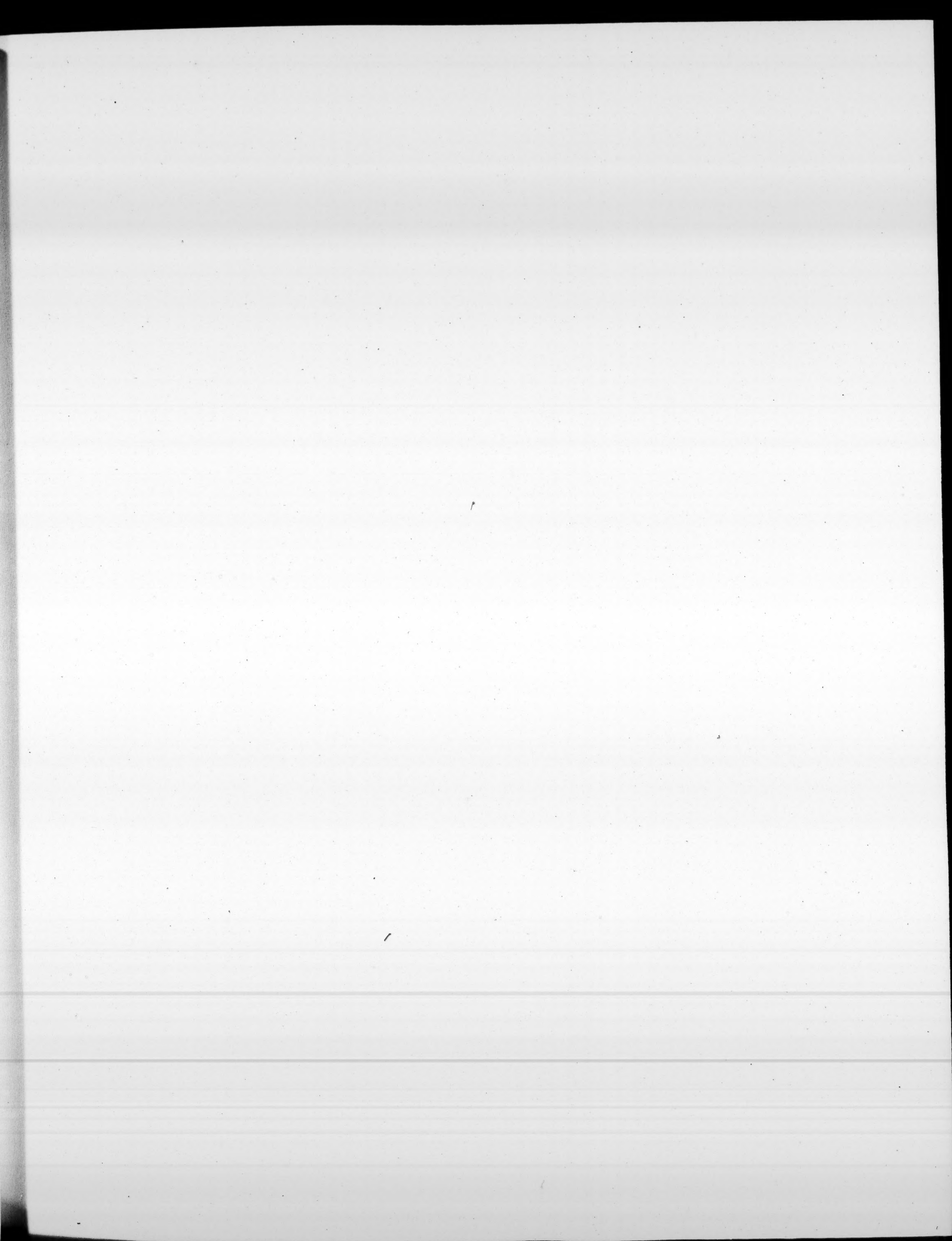
* Our light pieces lately had only two wheels, but since the train came from *Litchfield*, their carriages have been altered'd, and a *limber* added, it being found more convenient to go with four wheels than two.

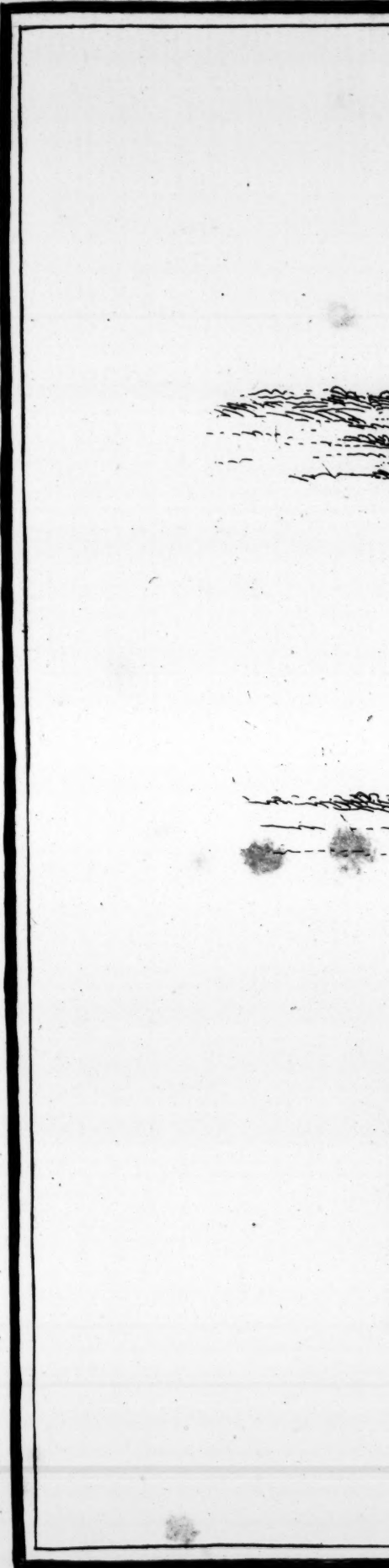
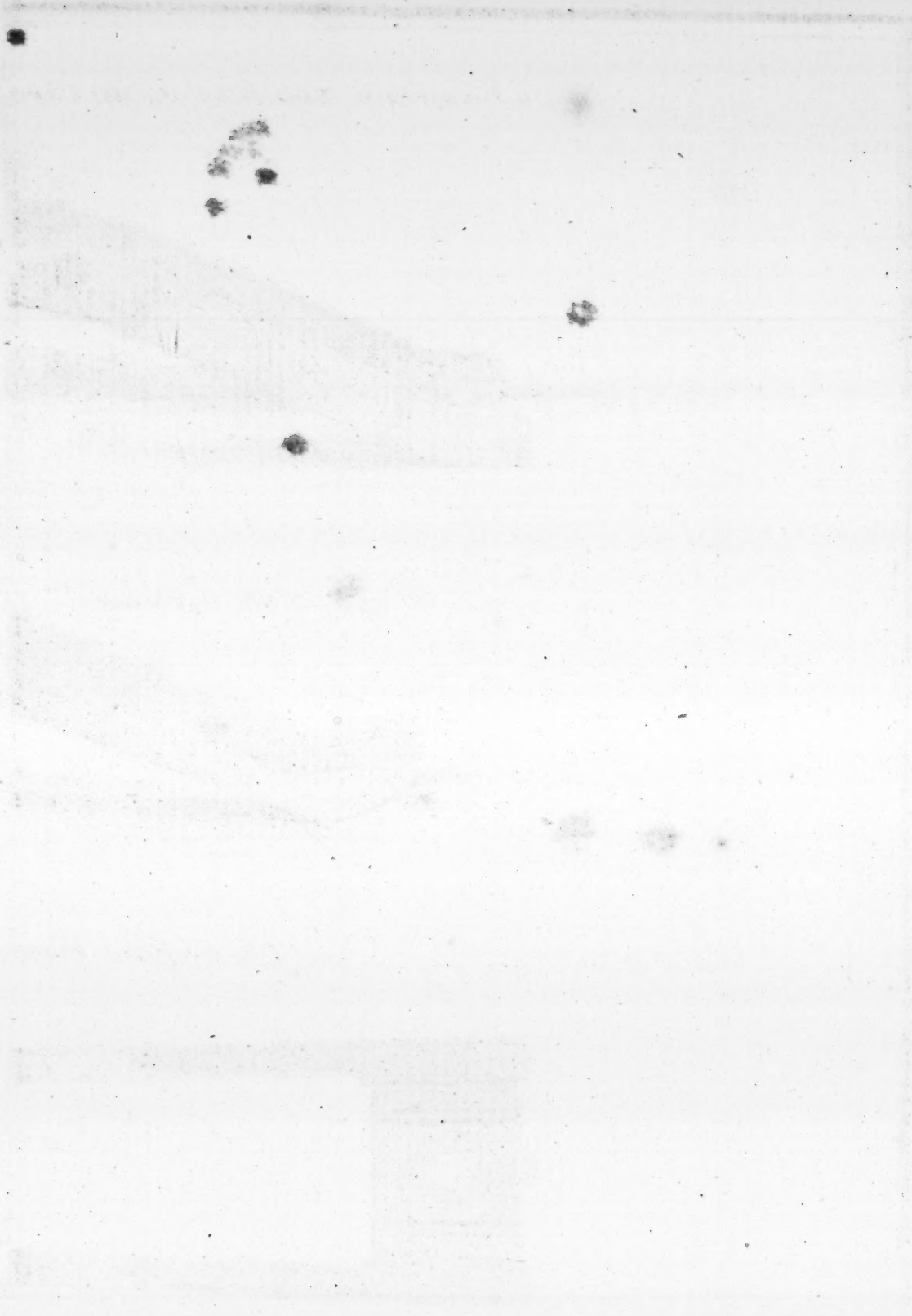
SECT. VI. *Of the manner of charging Cannon, and the Instruments necessary for that purpose.*

PL. III.

CANNON are charged by putting down into the bottom of the bore, first, a quantity of powder, one third, or one half, the weight of the ball. This is done with an instrument *a*, called a *ladle*, which is a kind of spoon, generally made of copper, fixed to the end of a staff *d*, which is called its *handle*. Upon the powder is put in a wad of hay, press'd or beat down very well with the instrument *e*, called a *rammer*. Upon this hay is put the ball, and to secure it in its place, another wad of hay is well rammed down upon it. The touch-hole of the piece is then filled with powder, from the upper part of which a little train is laid, that communicates with it. The use of this train is to prevent the explosion of the powder that fills the touch-hole from operating directly upon the instrument used to fire the piece, which in that case might be forced out of the hand of the gunner; an inconvenience that is prevented by setting fire to the end of the train.

In





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1



A Cannon mounted on its Carriage.

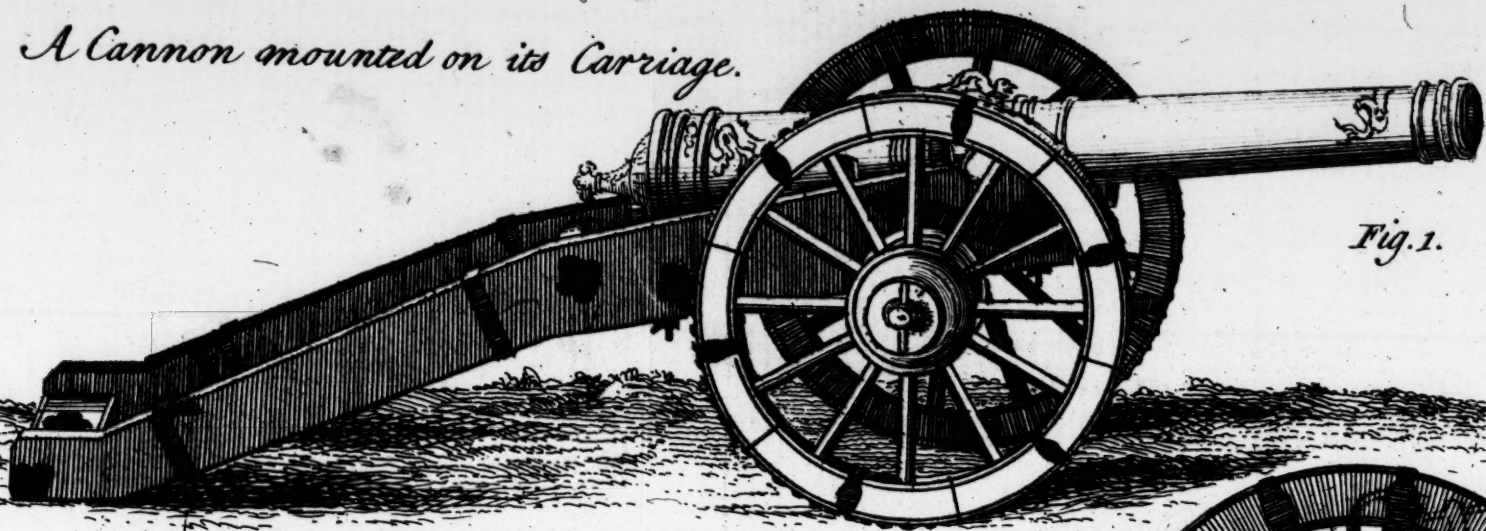


Fig. 1.

Profile of the Carriage.

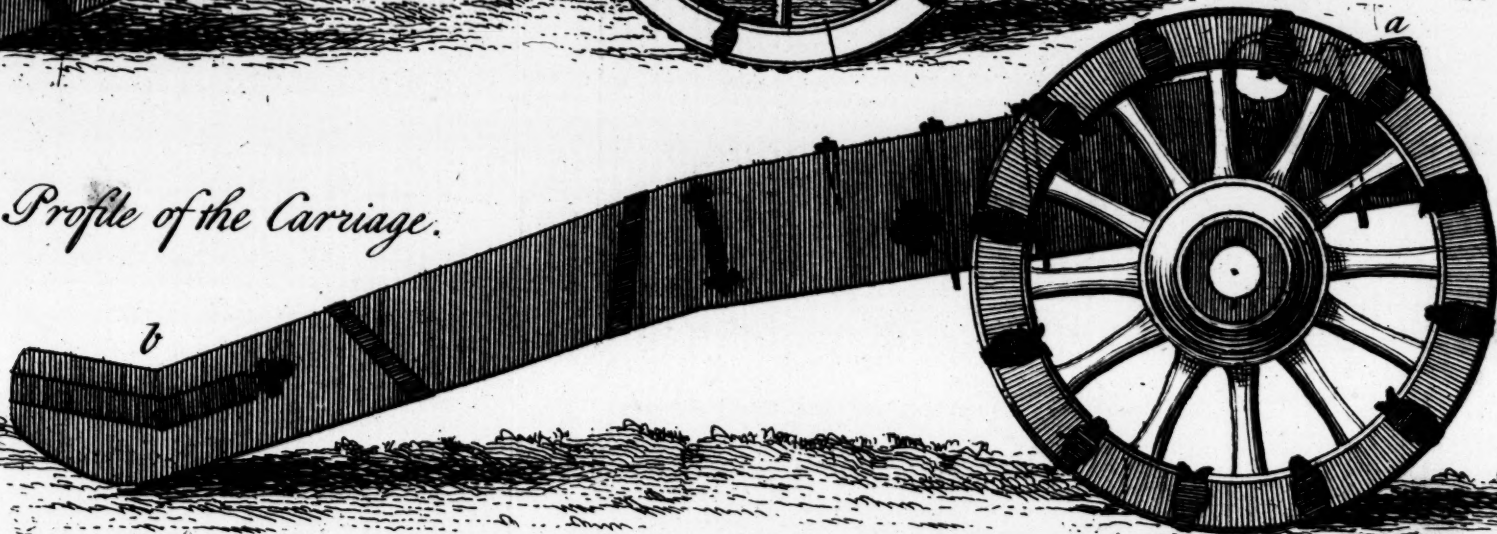


Fig. 2.

Plan of the Carriage.

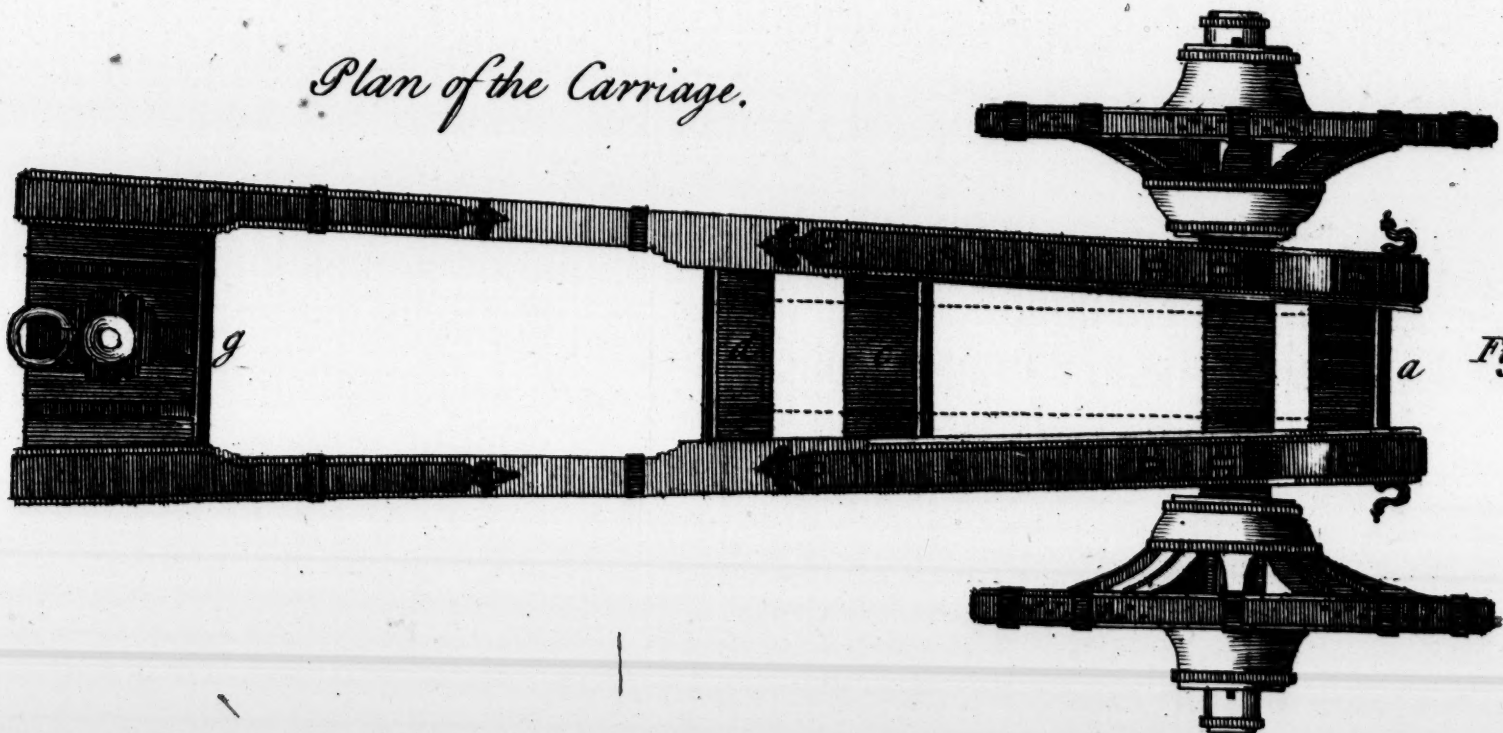
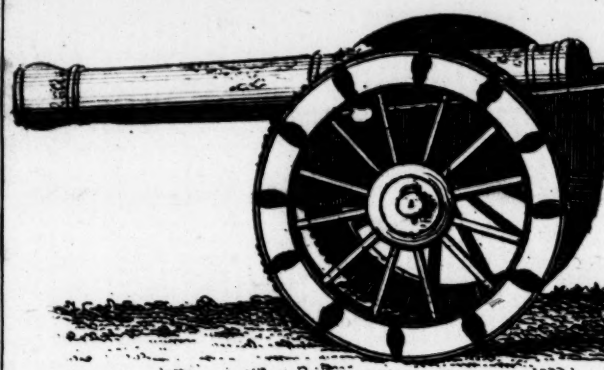
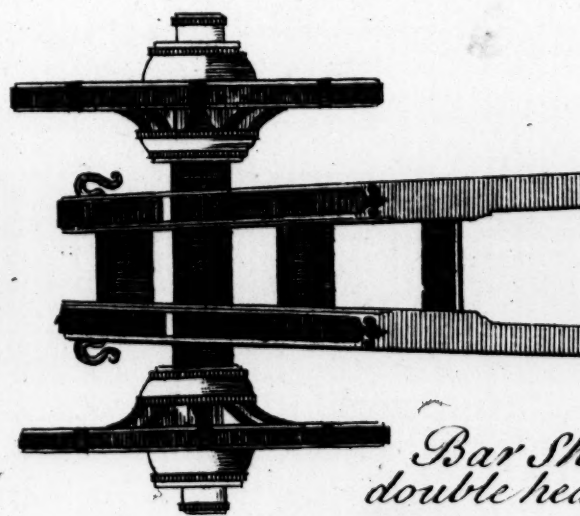


Fig. 3.

*A Cannon mounted
or fore Carriage*



Plan of the



*Bar Shot
double head*



Chain Shot.



mounted upon its Carriage to which y Limber
Carriage is also fastened.

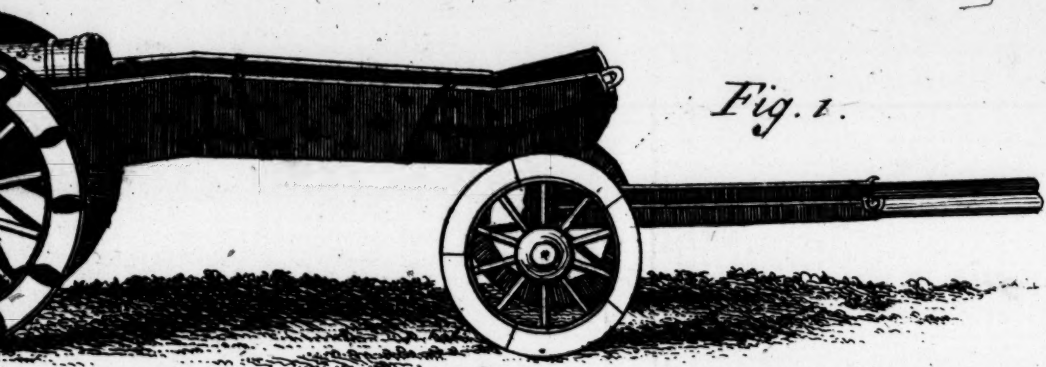


Fig. 1.

of the Carriage and the Limber -

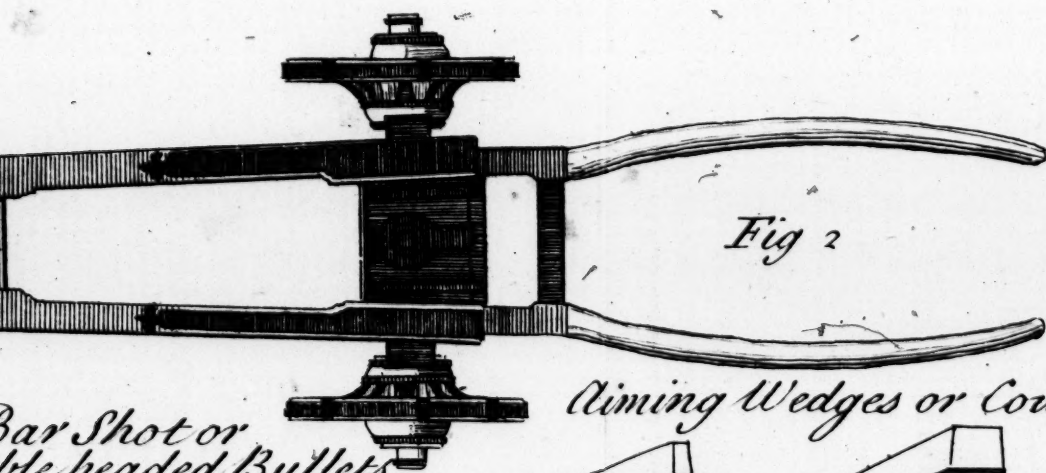


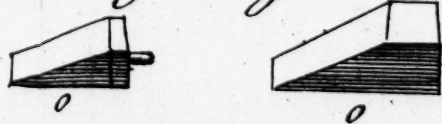
Fig. 2

Bar Shot or
ble headed Bullets.

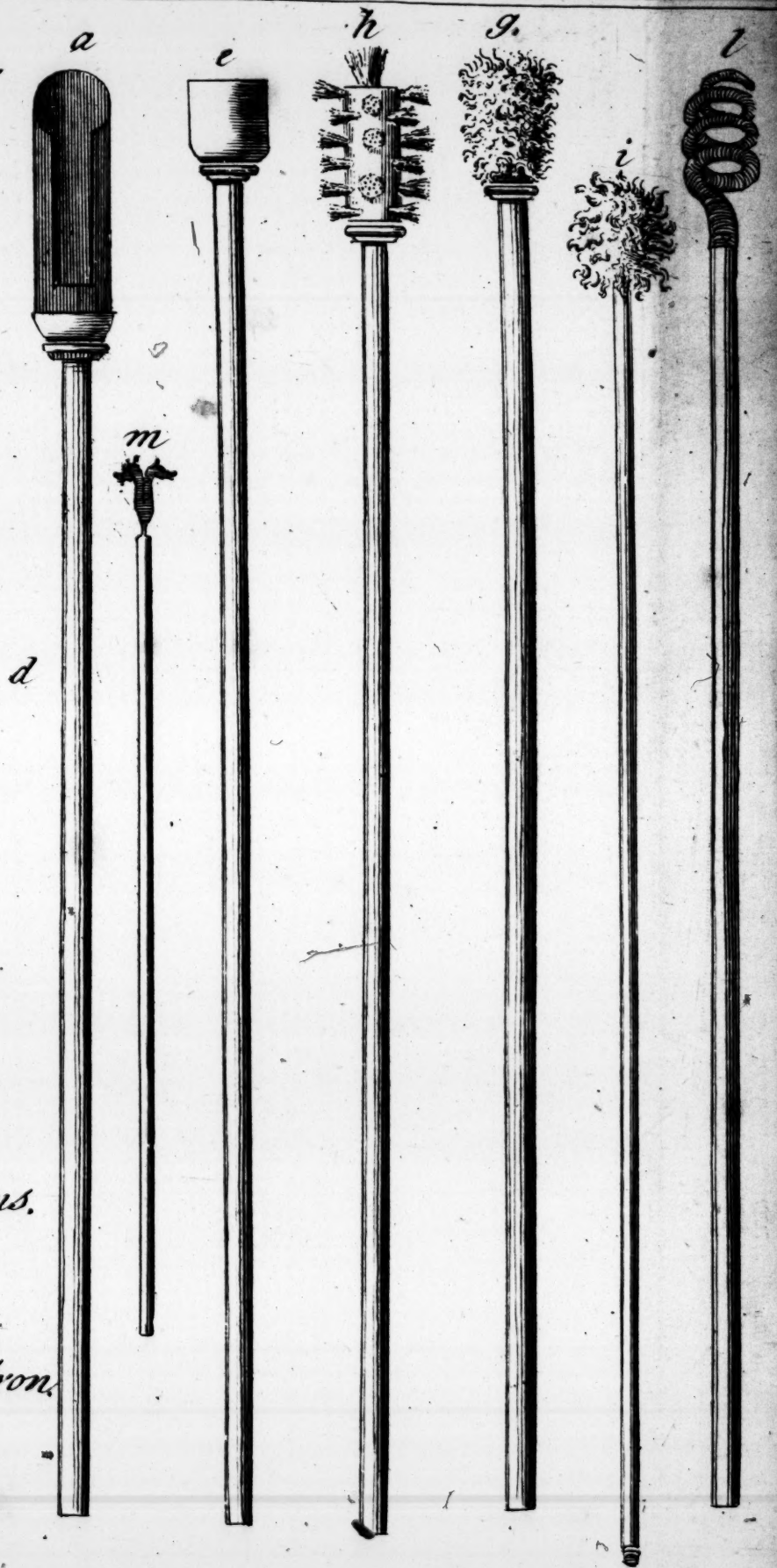


Shot.

Aiming Wedges or Coins.



Pent Sight Piece Priming Iron.



T. Jefferys sculp

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JERRY

1. The first of the three main parts of the book is the history of the book, which is a very interesting and well-written account of the book's development from its first publication in 1847 to the present day.

2. The second part of the book is a collection of essays by various authors, which are arranged in chronological order. These essays provide a detailed and comprehensive account of the book's history and development.

3. The third part of the book is a collection of essays by various authors, which are arranged in chronological order. These essays provide a detailed and comprehensive account of the book's history and development.

4. The fourth part of the book is a collection of essays by various authors, which are arranged in chronological order. These essays provide a detailed and comprehensive account of the book's history and development.

5. The fifth part of the book is a collection of essays by various authors, which are arranged in chronological order. These essays provide a detailed and comprehensive account of the book's history and development.

6. The sixth part of the book is a collection of essays by various authors, which are arranged in chronological order. These essays provide a detailed and comprehensive account of the book's history and development.

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9. The ninth part of the book is a collection of essays by various authors, which are arranged in chronological order. These essays provide a detailed and comprehensive account of the book's history and development.

10. The tenth part of the book is a collection of essays by various authors, which are arranged in chronological order. These essays provide a detailed and comprehensive account of the book's history and development.

In the modern pieces, a little guttur or channel is cut, about a line deep and six wide, to prevent the wind from dispersing or blowing away the train; this channel reaches from the touch-hole to the shield, on which is carved the king's arms.

The cannon being pointed at the place which the bullet is intended to strike, the train is fired, and the fire immediately communicated to the powder in the touch-hole, by which it is further communicated to that in the piece; and this powder being kindled dilates so as to occupy a much greater quantity of space than when in grains, and being thus dilated it makes an effort on every side to force itself out. The bullet making less resistance than the sides of the piece upon which the powder presses at the same time, is driven out by its whole force, and acquires that violent motion, the effect of which is well known to the world.

In *Plate III.* all the instruments necessary for charging cannon are represented. Besides those already described, there is the *maulkin*, or *spunge b*, which is used to clean the piece after firing, and to extinguish any sparks that may remain behind. This is a kind of brush, fixt to the end of a staff. To spunge a piece, is to put in this instrument, and with it clean well the cavity. The Figures *g* and *i* represent maulkins, or spunges, of a different kind, made of sheepskins, fixt to a proper handle. PLATE
III.

The wad-hook *l*, serves to draw the charge when necessary.

The picker, or priming-iron *q*, serves to clear the inside of the touch-hole, and render it fit to receive the prime, and is a kind of large iron *needle*.

The lint stock *m*, is a long staff, to the end of which a match is fastened to fire the piece.

The *Chapiteau n*, is a sort of little *pent-houfe*, made by two thin pieces of board, join'd together at top, so as to form an angle of about

about 100 degrees; this is set up over the touch-hole, to prevent the prime from being carried away by the wind, or wetted by the rain.

All the instruments above-mentioned, used in charging and managing cannon, are called *cannon furniture*.

SECT. VII. *Of the manner of Powder's taking fire.*

A Variety of experiments, made with great care and accuracy, prove that powder, when on fire, possesses at least 4000 times more space than when in grains: * therefore, if we suppose that the quantity of powder, with which a cannon is charged, occupies one fourth of a cube foot in grains, it will, when on fire, occupy the space of 1000 cube feet, or about 4 cube fathom. The same experiments also shew that powder takes fire circularly, *i. e.* it dilates itself equally round its centre. One grain of powder, fir'd in the centre of different concentric circles, round which grains of powder are placed, shall set fire to all those grains at once.

From hence it follows that powder, when fir'd in a cannon, makes at the same instant an equal effort on every part of the inside of the piece wherein it lies, in order to extend itself circularly every way. But as the resistance from the sides of the piece turns the action of the powder, so as to follow the direction of the bore of the cannon, when it presses upon the bullet
to

* Mr *Hawksbee* in the *Philos. Transf.* No. 295, relates the following experiment, made to prove that gunpowder operates by producing a durable elastic fluid: a red-hot iron was included in a receiver, and the receiver was exhausted; some gunpowder was then let fall on the iron, which took fire, and the mercurial gage descended on the explosion; and tho' it immediately ascended again, it never

rose to the height it first stood at, but continued depressed by a space proportioned to the quantity of powder which was let fall on the iron. The supposition of our author that gunpowder possesses a greater portion of space when fired, than in grains, seems to answer all the purposes of this elastic fluid, and differs from it little more than in terms.

to throw it out, it presses also on that part of the bore opposite the mouth, that is, upon the breech; and this gives the piece a motion backwards, which is called its *recoil*. The recoil in some degree diminishes the action of the powder on the bullet. But this cannot be avoided; for if the carriages were fixt, so as not to give way to this motion, the action of the powder, or the effort that causes the recoil, would tear them to pieces in a very short time.

SECT. VIII. *Of the invention of Spherical Chambers, the reason why they are disused, and of the shape of the interior part or bore of cannon.*

IT is evident that the greater the quantity of powder which takes fire at the same instant, the greater its effect will be upon the bullet. This gave rise, towards the end of the last century, to a new construction of the bore of cannon, by making a cavity in the form of a sphere a *little flattened*. The touch-hole being placed pretty near the middle of this cavity, which was larger than any other part of the bore, fired a greater quantity of powder at the same time than if the bore had been uniform; and the powder finding itself as it were bound up, and confined in this cavity, acted upon the bullet with more force and impetuosity than in the common pieces.

The design of this contrivance was, to throw a bullet from a piece shorter, lighter, and more easy of carriage than others, with the same degree of force as from those before used. Experience proved, that the construction of these pieces answered the end proposed; for, tho' much shorter than other cannon, and charged with a less quantity of powder, they produced the same effect.

D

But

But as it was difficult to clean the chamber after the piece had been fired, there frequently remained some sparks behind; so that, when it was necessary to fire the pieces as fast as possible, many cannoneers had their arms shot off as they were charging them; and besides, as the powder, before it forced itself out of the chamber, press'd on all sides with so great violence and impetuosity, in a very little time the carriages were broken to pieces, and render'd unserviceable; and, by a frequent repetition of this violent agitation, the piece acquired a very considerable recoil, and the direction of the bullet became uncertain. For these reasons this contrivance was entirely laid aside, and the greatest part of these pieces found in the arsenals and fortifications were re-cast, so that the cannon now used have a bore of the same diameter in all parts. See the figure of a twenty-four pounder of this invention in *Pl. IV. Fig. 1.*

PL. IV.
Fig. 1.

That part of the bore of the cannon, which receives the powder it is charged with, is called the *chamber*; and therefore the pieces with spherical or oblong cavities, were called *spherical chamber pieces*, and those used before and since that invention, are called *cylindrical chamber pieces*.

We have already said that the bore of cannon is in every part of equal diameters, but it must be observed, that this is not strictly true at present, except in 12, 8, and 4 pounders; for in 24 and 16 pounders, there is made at the bottom of the bore a little cylindrical chamber *a b*, which holds about 2 ounces of powder. In a 24 pounder this little chamber is one inch and an half diameter, and two inches and an half in depth; and in a 16 pounder it is one inch diameter, and one inch 10 lines in depth. The *pipe* of the touch-hole comes into this little chamber at about 9 lines from its inmost recess in 24 pounders, and at about 8 in 16 pounders.

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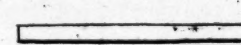
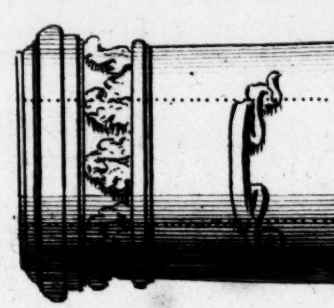
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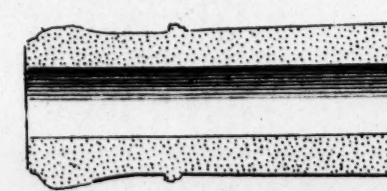
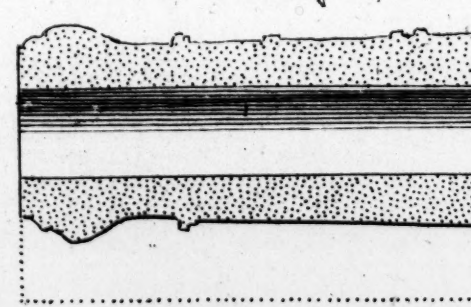
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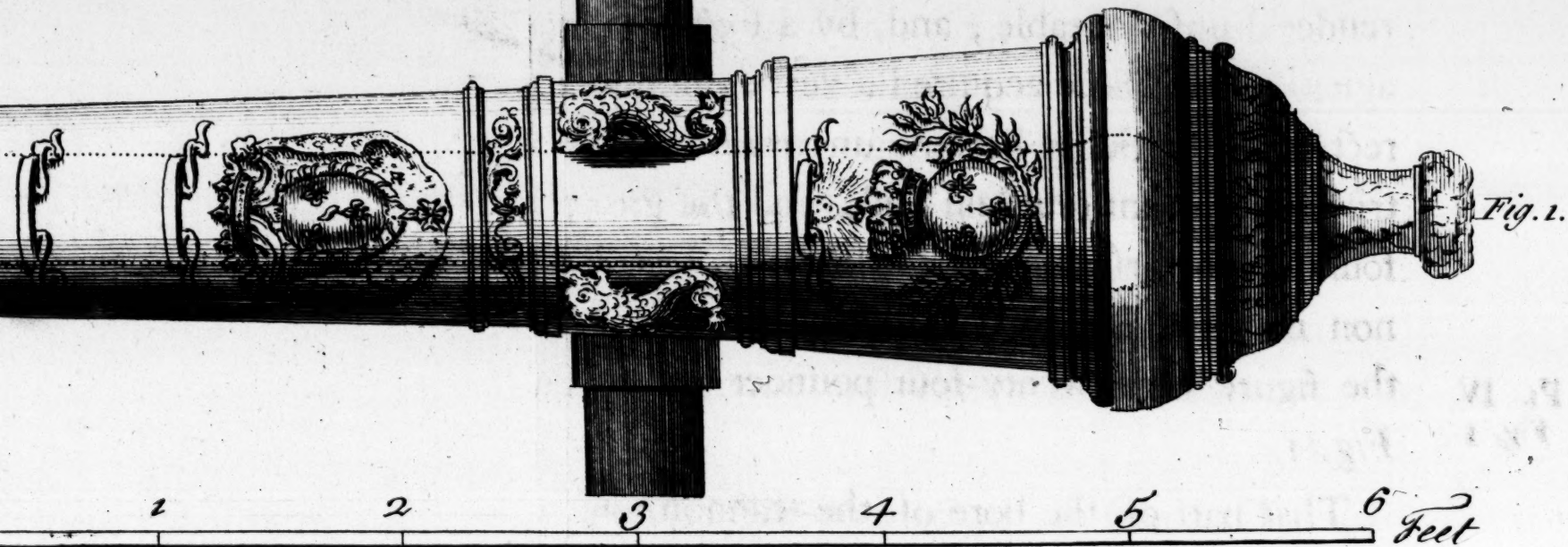
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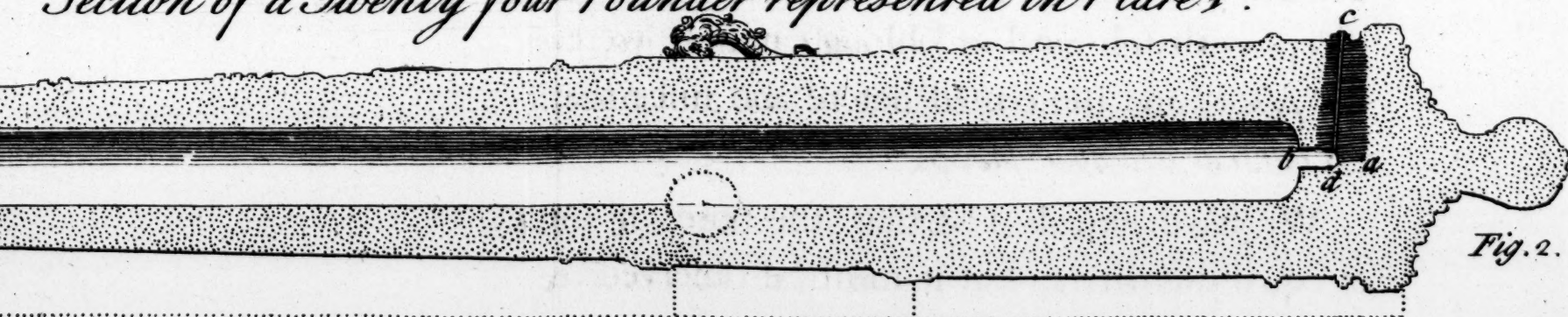


IV.

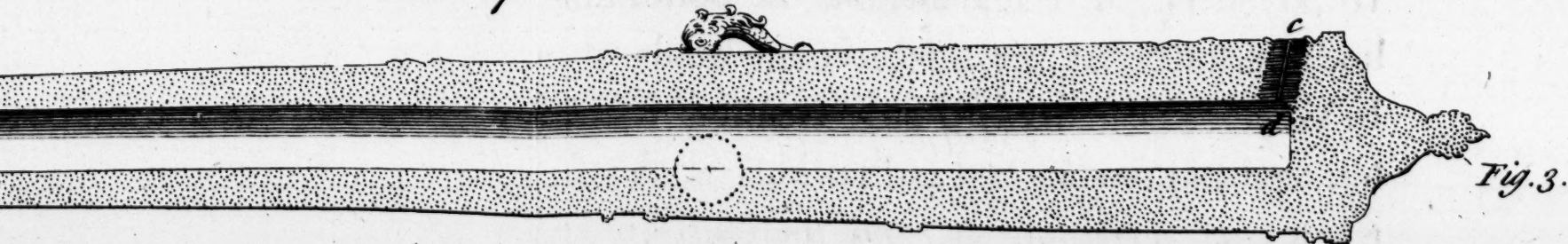
Twenty four Pounder wth a Sphoricall Chamber.



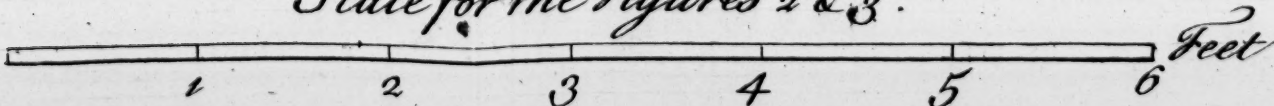
Section of a Twenty four Pounder represented in Plate 1.



Section of a Twelve Pounder.



Scale for the Figures 2 & 3.



T. Jefferys sculp.

The design of the carriage is to preserve the position of the gun in the case of a charge being fired. The carriage is designed to be used in the case of a charge being fired.

The carriage is designed to be used in the case of a charge being fired. The carriage is designed to be used in the case of a charge being fired. The carriage is designed to be used in the case of a charge being fired.

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The design of these chambers is, to preserve the touch-hole, by preventing the powder the cannon is charged with, from having an immediate effect on its *pipe*; pieces that are less than 16 pounders have not this chamber.

Figure 2, in *plate IV.* represents a 24 pounder divided longi- PL. IV.
tudinally, and shows the little chamber just mentioned *a b*, of Fig. 2.
which *fig. 3*, in *pl. I.* exhibits the plan.

Fig. 3, in *pl. IV.* is the section of a 12 pounder, in which it Fig. 3.
may be observ'd this chamber is wanting.

An author, who has lately written a treatise of artillery (2), which has receiv'd the recommendation of the royal academy of sciences, at the same time that he commends these little chambers for preserving the touch-hole, fears they may be liable to great inconveniences on account of their not being easily spunged. But nothing appears more easy than to remove this inconvenience; for there needs only to add to the common maulkin, or sponge, a little roll, about the same length and diameter with these chambers. They might even be spunged with the common sponge, which will clean the entrance and part of the cavity of these little chambers, which is sufficient, because by its disposition it is not so apt to retain any sparks of fire as the spherical chambers, these being narrower at their opening into the bore of the piece than in the middle, and therefore the metal next the opening may easily stop and retain some little particles of fire in the spherical concave; but our new little chambers, which form a small canal entirely uniform and cylindrical, are not liable to produce the same accidents.

The adoption of this little chamber into its artillery by *France* is a further proof of its excellence; for it may be presumed we

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(2) *A new Treatise of the Mechanism of Artillery*; by M. *Dulacq*, captain of artillery to the king of *Sardinia*. Printed at *Paris*.

should not have adopted it, without knowing its advantage by experience, which in these matters ought to over-rule all theoretical conclusions.

The extremity of the bore, next the breech, is in all pieces rounded by an arch, the radius of which is about the 4th of the caliber of the bore. This rounding renders it more easily and more perfectly spunged; it also augments the strength of the metal towards the breech and touch-hole. In 12 pounders the pipe of the touch-hole enters the bore at 8 lines from the bottom, in 8 pounders at 7 lines, and in 4 pounders at 6.

SECT. IX. *Of the manner of pointing Cannon.*

TO direct or point cannon towards the place you would strike with the bullet, the breech must be raised by means of a wedge, or coin *o*, which is placed under it on the *bed* of the carriage, and is called the *aiming wedge*.

This wedge, by being driven under the breech, raises it up, and lowers the mouth, which is therefore to be done till the piece lies in the direction desired. When the piece is to be aimed from any considerable height to a place much beneath it, two or three of these wedges are made use of, laid one on another.

Cannon being heavier toward the breech than mouth, and making in shape a kind of frustum of a cone, a line supposed to pass from end to end thro' the middle of the bore, as *a b*, will not be parallel to the upper part of the piece *c g*; therefore if a piece be levelled by a continuation of the line *c g*, the bullet, instead of passing in that direction to *d*, will go to *b* the continuation of the line *a b*; that is, it will go higher than the point to which it was levelled. To remove this inconveniency, there must be placed on the chace, near

near the muzzle, a piece of wood α , concave on one side, that it may answer the convexity of the cannon, so as to lie firm, its top being just as high above the piece, as the metal is thicker at the breech than at the mouth. This is called *the sight-piece*, and serves, by guiding the eye, to discharge the bullet in the direction desired. By its help the line of sight becomes parallel to the line supposed to pass through the middle of the bore, that is, parallel to the line the bullet ought to describe, supposing it to move in a right line. So that levelling the upper part of the breech, and the upper part of the sight, with a given point, the bullet discharged in that direction will be carried towards that point, only lower just the semidiameter of the cannon at its breech. Therefore, if a piece be levelled to a point half the diameter of the breech higher, the bullet will strike precisely the point intended to be hit. But this must be understood exclusive of all the accidents that may, and that in practice actually do, vary the direction of the bullet.

SECT. X. *Of the different Ranges of Cannon.*

IT has been said above, that the bullet is supposed in its passage to describe a right line, but, strictly speaking, it does not, because its weight inclines it to the earth every instant of its motion. But as at the time of its first coming out of the piece its motion is very rapid, the weight does not sensibly affect it * in the first instants of its motion; so that the line it then describes is apparently straight, and the extent of this line is called the *point blank* range

* A celebrated *Italian* author, speaking of the tract described by the flight of bullets, compares what is called their *point blank range*, and falsely thought to be a right line by many authors, to the

surface of the sea; which, though it appears to be a plain when partially considered, is undoubtedly incurvated round the centre of the earth.

range of the piece. This range may be defined, *the extent of the apparent right line described by a bullet discharged from a cannon.* This point blank range is much less than the greatest range, or random shot, of the piece; but the cannon cannot be levelled, or, as it is generally expressed, *pointed*, at an object intended to be hit, if that object is not within the distance of the point blank range: for beyond that the stroke is very uncertain.

Thus cannon have two different shots; the first called their *point blank* shot, just above described; the second, their *random* shot. A piece is said to fire at random shot, when the breech rests upon the bed of the carriage, and makes pretty near an angle of 45 degrees with the horizon. In this situation of the piece the bullet falls at the greatest possible distance the force it is thrown out with can carry it to; but as in this case it cannot be directed to any determinate object, a piece is never fired thus, but at a company of men, or a place where it cannot fail of doing mischief to the persons posted in it when it falls.

Two experiments have been made to examine and ascertain the ranges of different pieces of cannon, the result of which is, that their point-blank shot is about 300 fathom.

M. *St Remy*, in his *Memoirs*, mentions several experiments made by M. *Du Metz*, lieutenant general of the king's forces, and lieutenant of the artillery in *Flanders*, by which, the pieces being fired at random shot, and charged with two thirds of powder of the weight of the bullet, it appeared

					fathom
That a 24 pounder carried					2250
16	--	--	--		2020
12	--	--	--		1870
8	--	--	--		1660
4	--	--	--		1520

With

With what care soever these experiments are made, so many different things concur to augment or diminish the distance of the shot, that this account cannot be absolutely depended upon, but should only be regarded as giving pretty nearly the extent of the shot.

SECT. XI. *Of the Ricochet*, or rolling and bounding shot.*

BESIDES the two sorts of shot just mentioned, there is the *Ricochet*, invented by monsieur the marshal *de Vauban*, and used by him in 1697 at the siege of *Aeth*.

To fire a piece by way of the *ricochet*, is only to charge the cannon with no more powder than is sufficient to carry the bullet along the face of the works attacked. The bullet discharged in this manner goes rolling and bounding, killing and maiming all it meets in its course, and creates much more disorder by going thus slowly along, than it could if thrown from the piece with great violence and speed.

The quantity of powder necessary for the *ricochet* is not known but by trying different quantities till the right is hit upon, which being found they continue to fire the piece with that charge.

* *Ricoche* signifies *duck and drake*, stone thrown almost horizontally into a name given to the bounding of a flat the water.

SECT. XII. *Of the quantity of Powder necessary for the charging CANNON.*

IT was the opinion of engineers, formerly, that by charging the pieces high, the bullet was thrown to a greater distance; and it was their custom to charge them with two thirds, or even the whole,

whole, weight of the bullet, in order to impel it with the greater velocity, as appears by the authors who have heretofore written on the subject. But it has been discovered since, at least in *France*, that the half, or one third, of the weight of its bullet is the fittest charge for the piece.

If the whole quantity of powder with which cannon is charged could take fire at the same instant, it is apparent that the greater the quantity the greater the velocity communicated to the bullet; but tho' the time of its inflammation is very short, it may yet be conceived as divided into many instants. The first instant the powder begins to dilate and impel the bullet before it; and if it has force enough to expel it from the piece before the whole charge is inflamed, that part which is left to take fire afterwards wou'd absolutely produce no effect at all on the bullet. So that a charge of extraordinary force does not accelerate the velocity of the bullet; and hence it follows that the piece ought to be charged with no greater quantity of powder, than can take fire while the bullet is passing through the chace of the piece. This quantity may be determined by experiment; not however with great exactness, because the force of the powder will considerably vary, the effects of which, although produced with an equal quantity of the same powder, have frequently a very sensible difference; and for this reason experiments made on this occasion ought to be regarded but as the means of knowing nearly the quantity of powder required.

A cannon which shall be too short, and another which shall be too long, will not either of them throw a bullet to the greatest possible distance; a piece which will not give time for its whole charge of powder to take fire before it discharges the bullet, discharges it with only a part of the force of the powder; and in a cannon, the chace of which is too long, so that the bullet cannot pass through

through the vacant cylinder before the entire inflammation of the charge, the bullet will lose by its friction, and the resistance of the air, part of the force it received from the powder, and so will not be thrown to the greatest distance to which that quantity of powder would have carried it. And indeed, as M. *Belidor* has observed in his *Course of Mathematics*, experience has shown that the culverin of *Nancy*, which is longer than our pieces (it being near 22 feet) does not carry so far as pieces of the common length; tho' this is contrary to the vulgar opinion, which gives this piece a much greater range.

SECT. XIII. *Of the manner of determining the Length of Cannon, with respect to a given Charge of Powder; or rather when the Length of the Piece is given, how to find the Quantity of Powder proper to give the Bullet its greatest possible Force.*

IF the precise time of the whole charge of the powder's being fired could be known, as well as how far the ball will have moved in that time, it would be easy to determine the most advantageous length of a piece with respect to a given charge. Though this knowledge labours under many difficulties, not only in estimating the action of the powder in the several instants of its taking fire, but also by the friction of the bullet in its passage through the chace of the piece, which in part diminishes the effect of the powder upon it, by the resistance of the air at its coming out of the piece, &c. yet the following is a very simple method of determining this length with an exactness sufficient for practice.

A very long piece must be provided, and fired under any given angle, with a given quantity of powder. Examine the range of
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the bullet in the first firing, which will be less than ordinary, because the piece is longer than it ought to be ; cut off two or three inches of the bore, and fire it a second time ; continue thus to diminish the length of the piece at every firing, so long as the range of the shot increases, and when you have a range less than the former, divide into two equal parts the piece last cut off, and subtract that half from the length of the piece at the last firing but one, or add it to the length of the piece at the last firing, and you will have the length of a piece, proper to throw a bullet to the greatest distance to which that charge will carry it, determined with a sufficient degree of exactness. M. *Bigot de Morogues* proposes this method, which had before been directed by M. *Belidor* in his *course of mathematics*. But at the same time he observes, that this experiment is subject to the inconveniency of having pieces too long to manage, and remove from place to place, without great difficulty ; he, therefore, thinks it better to prevent this inconvenience by adjusting the charge to the length, rather than the length to the charge : And supposing the length of the piece ascertained, as, for instance, that now fix'd by the ordinance just mentioned, it is easy to find the proper charge, by firing it successively with different quantities, and observing which carries the bullet to the greatest distance.

In all these experiments especial care must be taken that the piece at every firing is exactly in the same situation, and charged with the same powder.

Several experiments were made at *La Fere*, in the month of *October*, 1739, to adjust in this manner the charge to the piece ; by which it appeared,

That 24, 16, 12, and 8 pounders ought to be charged with no more than one third the weight of the bullet, and that with this charge they produced the greatest effect of which they were capable, or rather that 24 pounders require for charge 9 pounds of powder,

powder, 16 pounders 6 pounds, 12 pounders 5 pounds, and 8 pounders 3; larger charges than these not in the least augmenting the flight of the bullet.

As to the 4 pounder, its proper charge has been found to be 2 pound, that is, half the weight of its bullet. If this piece requires a stronger charge in proportion to its bullet than others, it is, says M. *Belidor*, because it is longer than others in proportion to its bore.

SECT. XIV. *Of the use of the Wad, with which the Powder in a Piece is covered.*

IT was examined, during the preceding experiments, whether the wad, or the ramming it down more or less, increased the flight of the shot; and it appeared that the same quantity of powder, whether it was covered with a wad, rammed down as usual, or not, always had very nearly the same effect on the ball; from whence it was concluded that a wad, bigger or less, or more or less rammed down, contributed not at all to the force of the piece.

The wad is necessary to keep the charge of powder together in the piece, and inclose it in the chamber, so as to prevent its dilating, when fired, around the sides of the bullet by its vent, as it is passing through the bore, which would lessen the action of the powder upon it; but as the wad cannot be fastened to the sides of the bore, the moment the powder takes fire, it is carried away with so little resistance, that it cannot in any degree retard the effect of the explosion, or give time for the entire inflammation of the charge.

This reasoning may be also apply'd to the wad that covers the bullet, which notwithstanding is absolutely necessary to prevent

its rolling out when the piece is fired horizontally, or pointed downwards.

SECT. XV. *Of the Number of Times the same Cannon may be fired successively.*

THE same piece cannot be fired more than a certain number of times successively, because the metal, when grown very hot, is softer, and its resistance less, by which means the piece is frequently bent, and sometimes burst; the touch-hole also widens, and grows so large, that, by affording too much vent to the powder, its effect is greatly lessened on the bullet; this, aperture will even enlarge itself to such a degree, that the whole force of the powder shall evacuate by it, and scarce act at all upon the bullet.

It has been experienced, according to M. St Remy, that a 24 pounder may be fired 90, 100, or even 120 times in 24 hours, as is usually done in sieges, which is 5 times an hour; but great care must be taken to cool, or refresh the piece, after firing 10 or 12 times. This is done by dipping the maulkin into water, and passing it several times up and down the bore of the piece.

When a piece has been fired many times successively as fast as it could be charged, and the metal is perceived to grow hot, the charge should be diminished, because, as has been before observed, the metal at this time is capable of less resistance, and may therefore be damaged by the usual charge.

It may not be amiss to observe here, that the range of cannon is greater in the morning, and at night, than at noon; and in cold than in hot weather. The reason is, that at these times the air being less heated, gives less way to the dilatation of the powder, which

which being by this means as it were confined to a less sphere of action, must in proportion have a stronger effect.

Many experiments at the academy of *La Fere* have demonstrated the truth of this extraordinary circumstance, and are recited by M. *Belidor* in his *Bombardier Francois*, and by M. *Bigot de Morogues* in his book *De l'application des forces centrales aux effets de la poudre a Canon*.

SECT. XVI. *Of the Method taken to remedy the Widening of the Touch-hole, or, which is the same thing, to put in a new Piece of Metal.*

IT has been observed that, for a cannon to have its total effect, the touch-hole must not be too large. When through often firing this inconveniency happens, what is called an engraftment is put in. This is done by pouring a quantity of new metal into the touch-hole, sufficient to fill it up entirely; first making the piece very hot, that the new metal, as it runs in, may the more perfectly unite with the old. When the piece is cooled, a new touch-hole is drilled in the place of the old one. That this new metal, as it runs into the touch-hole, may not go thro' into the bore, the piece is filled with sand, well rammed down, about as high as the handles.

As it is very difficult to make the new metal, poured into the touch-hole, unite perfectly with the metal of the piece, the Chevalier *de St Julien*, in his book *De la forge de Vulcain*, proposes that the touch-hole be enlarged two inches quite through to the bore as usual, and that there be made about this aperture, at three or four inches distance, four holes in four different places, in an oblique direction, so as to meet and terminate about the middle of the touch-

touch-hole, between the outer and inner side of the metal ; these holes must each of them be one inch in diameter at least. There must then be procured an instrument of wood, not unlike a rammer, which must exactly fit the bore of the piece ; upon the head of this kind of rammer a hole must be made half an inch deep, cut circularly, and so that the bottom of it may give a superficial convex parallel to that of the outside ; this must be lined with iron of a convex form, one or two lines thick ; after this 5 or 600 weight of metal must be melted, the cannon well heated, and this rammer introduced into the bore ; the hole at the end of it must exactly answer that of the touch-hole, and be placed exactly under it, the cannon being so placed as that the touch-hole may be exactly perpendicular to the horizon ; the metal must be run into all the holes above directed to be pierced ; after these are filled, and the piece is cool, the touch-hole will be found perfectly closed up, and capable to resist the utmost effort of any quantity of powder, the cannon may afterwards be charged with, as evidently appears from the nature of this contrivance. But to get out the rammer is now the question ; in order to effect this, precaution must be taken that it be made in two pieces, and then the under one being first drawn out, the other will easily follow. The new touch-hole is then pierced as usual, with an instrument called a *Drill*, which is the reason this operation is called indifferently *Drilling*, or boring a touch-hole.

Different inventions have been from time to time proposed, to lessen the action of the powder on the pipe of the touch-hole ; but as they were all attended with inconveniences, the ancient manner is still preserved, which is, to begin to bore the touch-hole on that part of the cannon which nearly corresponds with the end of the bore, and to continue it in an oblique direction till it comes
into

into the bore at some lines distance from its extremity, as has been said above.

Figures 2 and 3 in Plate IV. show the disposition of the pipe of the touch-hole *c a*. It is bored in the middle of a piece of fine copper of the figure of the frustum of a cone inverted.

PL. IV.
Fig. 2. 3.

The *figures* above it show this piece of copper, which is distinguished from the metal of the piece, by being shadow'd or hatch'd in a particular manner. This piece of metal contributes to preserve the touch-hole, by resisting the effect of the powder more forcibly than the metal of which the cannon is made.

SECT. XVII. *Of the manner of nailing up Cannon, or stopping the Touch-hole, so as to render the Piece unserviceable.*

WHEN circumstances make it necessary to abandon cannon to the enemy, or the enemy's cannon are seized, and it is not however possible to take them away, it is proper to nail them up, in order to render them useless.

To nail up cannon, is forcibly to drive, with an heavy hammer, a large steel nail into the touch-hole; when it is thus driven as far as it will go, they strike it with the hammer on one side, so as to break it off close to the piece, that no part of it may remain to be taken hold of, in order to draw it out. Cannon nailed up are absolutely useless, and a new touch-hole must be bored, or the piece new cast.

The first person who nailed up cannon, according to the Chevalier *de Ville*, was one *Gaspar Vimercatus* of *Bremen*, who nail'd up the artillery of *Sigismund Malatesta*.

The same author proposes (instead of nails) to stop the touch-hole

hole with small flints, or river pebbles, about the size of peas; and he insists that by filling up the touch-hole with these, well beat in, the piece will be more effectually nail'd up than in the common way.

Sometimes a cannon which has been nail'd up may again be rendered serviceable, without piercing a new touch-hole, by blowing out the nail which has been driven in to stop it up.

For this purpose the piece must be charged very high, and the charge covered with a tampion, pressed very tight into the piece, which is fired by means of a match rubbed over with the composition of a fuse, which communicates with the charge, and comes out at the mouth of the piece. The charge of powder taking fire sometimes makes an effort on the nail in the touch-hole, sufficient to drive it out, especially if it be not clenched on the inside (It is clenched, when time permits, by bending or turning back the point with a rammer introduced into the bore for that purpose). When the powder does not blow out the nail, a new piece of metal must be inserted, and a new touch-hole bored, to render the piece again serviceable.

Besides nailing up, another method has been found of rendering a piece of cannon unserviceable, which is, by forcing into it a bullet of a larger caliber than that proper to the piece. The nailing up is remedied in the manner just mentioned, but no expedient has been yet found to render cannon again serviceable after a bullet has been driven into them, they must absolutely be re-cast. This last expedient is on this account preferable to the first, but then it is not done in so short a time.

SECT. XVIII. *Of red-hot Bullets.*

WHEN a town is intended to be fired, or magazines of powder battered, the cannon are charged with red bullets, that is, bullets made red-hot upon an iron grate contrived for that purpose, and put into the cannon with tongs, letting them fall immediately on the wadding or turf that covers the powder, and then instantly firing the piece, that the bullet itself may not kindle the powder, which would much lessen its force. To fire a red-hot bullet it is necessary the breech of the cannon should rest on the bed of the carriage, because in a horizontal or inclining situation the bullet might roll in the chace of the piece, and even fall out; for it cannot be secured in its place by ramming upon it a wadding of hay or turf, as other bullets are, for fear it should fire the powder during the operation. Red-hot bullets are seldom fired but from 8 or 4 pounders, because the getting heavier bullets into the piece would be attended with too much difficulty and trouble.

Red-hot bullets are also used to be fired at ships, because they may enter the powder-room, and blow up the vessel.

SECT. XIX. *Of Gargouges and Cartouches.*

UPON emergencies, when it is necessary to fire the piece as fast as possible, instruments are used, called gargouges, and cartouches.

The gargouge is a cylindrical roll, of the same diameter as the bore of the piece, filled with powder to the height of about 3 semi-diameters, or as far as is judged necessary to discharge the bullet; this is properly the charge of powder for the piece, inclosed in a kind of case of linen, paper, or parchment.

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The Cartouche is also a kind of case, or roll (as the gargouge) which holds the bullets, leaden balls, nails, and old iron, &c. with which the piece is to be charged; this is made of linen or tin.

Sometimes the gargouge and cartouch are joined together, and the compound resulting from thence is indefinitely called the *Cartouche*. The manner of using these, is only conveying them to the bottom of the piece, after which the cannoneer pierces them with a picker through the touch-hole, then primes and fires the piece.

It is evident that firing with cartouches can only be used with respect to objects that be near, because the lead, old iron, &c. continued in the cartouche, being in separate and small pieces, have not solidity enough to be thrown so far as a small bullet.

A bullet may be used with the gargouge, and in that case, after the piece has received part of its charge, the bullet is put in upon it, as in common charges. The cartouche also may be used without the gargouge; and in that case the charge of powder is rammed down as usual, and upon the wad that covers it is put the lead, iron, and whatever else makes up the cartouche.

All cannon which are fired, charged after any of these methods, are generally said to be fired with cartouche, and have a much greater effect than when charged with a bullet only, because the shot, nails, &c. dispersing as they go out of the piece, may in the same instant do execution in many different places.

Cartouches of linen and paper are very dangerous, because apt to leave some little shreds on fire behind them in the piece, which small sparks are sufficient to fire the next cartouche that is put in, and this cannot fail to produce melancholy accidents; those of parchment are better, because they leave no fire behind them. The

ill consequences of the former are prevented by spunging the piece, after every firing, with the maulkin dipped in water.

The 24 and 16 pounders, which at the bottom of the bore have the small chambers already mentioned, are neither fit to be fired with cartouch, nor designed for it, the common cannon only being used for this purpose. The others are rather employed to destroy the works and the fortifications of towns, than to fire upon parties of men; it would therefore be of very little use, if they were capable of being fired with cartouches.

There are also cartouches for the musket; these contain the entire charge, that is to say, the whole quantity of powder and ball these pieces are fired with. When the soldier makes use of these cartouches, he tears off that end of the cartouch which is to lie next to the touch-hole pan with his teeth, and having rammed it down to the bottom of the barrel of the musket, he has nothing to do but to prime*, and he is ready to fire. These cartouches are commonly used in engagements, to shorten the time in charging.

Besides bullets and cartouche shot, with which it has already been said cannon are charged, two bullets chained together are sometimes made use of. These are principally used at sea, because better fitted to break the masts and rigging than single balls, and are called chain-shot. Double-headed bullets, or bar-shot, have been also sometimes introduced in the sea service: These are bullets cut into two equal parts, and joined together by a small kind of iron bar; the middle is filled with a composition, and the whole covered with linen dipped in brimstone; the cannon in firing fires also the combustibles, or composition of this bullet, which sets fire to the sails of the vessel. One of the heads of this bullet has an hole

PL. III.
Fig. 2.

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* Our method is first to bite off the end of the *cartouche*, and prime with part of the powder contained in it, and then charge the piece with the remainder.

to receive a fuze, which communicating with the charge of the cannon sets fire to the bullet.

After the cannon the most considerable machine, or instrument, used at sieges, is the mortar.

C H A



P. III.

SECT. I.

Of the MORTAR.

THE mortar is a sort of cannon, made of the like metal, but much shorter, and wider, than the common cannon; the kind of bullet, for the discharge of which this piece is generally used, is called a *bomb*.

The name of *mortar* given to this piece might, perhaps, be taken from its resemblance to a common mortar.

The bomb is a great hollow bullet, concave within, which is filled with powder, and by means of the mortar is discharged upon the place intended to be destroyed. These bombs produce two effects, *viz.* that of ruining the most substantial buildings by their weight, and that of creating great disorder by their splinters; for when the powder they are charged with takes fire, its effort breaks or bursts the bomb, and explodes the splinters on every side with great violence.

The use of mortars is very ancient; M. *Blondell* thinks they have been used as long as any other cannon, but is of opinion they were then employed only in throwing stones, and red-hot bullets; he thinks too that the first bombs were thrown in 1588 at the siege of *Wachtendonck*, a town in the dutchy of *Gueldres*. But be
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this as it may, they were not used in our army till the first siege of *La Motte* in 1634. *Lewis* the 13th sent for Mr *Maltus*, an *English* engineer, from *Holland*, who made use of bombs in several sieges with success, and was killed at that of *Gravelines* in 1658. He had remarked, says M. *Blondell*, a post where he designed to force the trenches in the night, and being desirous to show the place to the general officer, he leaped into the trenches to reconnoitre the situation; the general officer did the like after him, but not having well reconnoitred the place, he desired *Maltus* to jump in a second time, to remark it with more exactness; *Maltus* consented, and leaping received in the air a musket shot in his head, which made it said jestingly in the army, that he was kill'd flying.

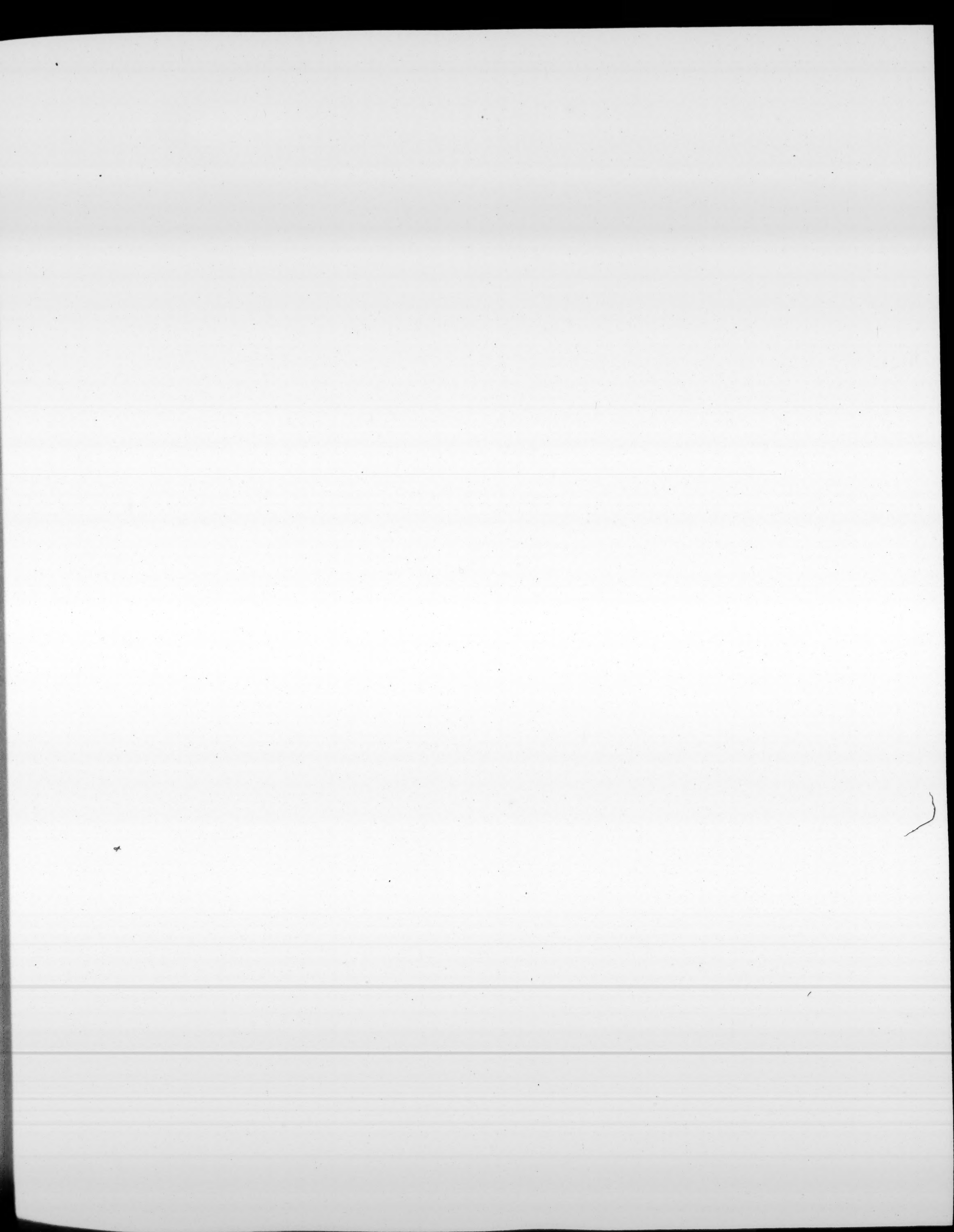
The aperture *l* of the mortar is called its mouth, the opposite part *a*, its breech; *b* is its touch-hole, which corresponds to the inner bottom, or the place that receives its charge of powder; this place is called the chamber of the mortar; the two prominences *o c* are its trunnions, or the parts by which it is supported on its carriage; *d* is the astragal of the touch-hole, *e* the first renfort, *f* the platband of the renfort, with the handle by which the mortar is suspended and managed, and its mouldings; *g* is the chace, *h* the neck astragal, *i* the first collar or neck, *k* the rim or moulding of the muzzle; the concave part of the piece, from the mouth to the mouldings of the platband, is called the bore of the mortar, and the chamber is the rest of the cavity quite to the breech.

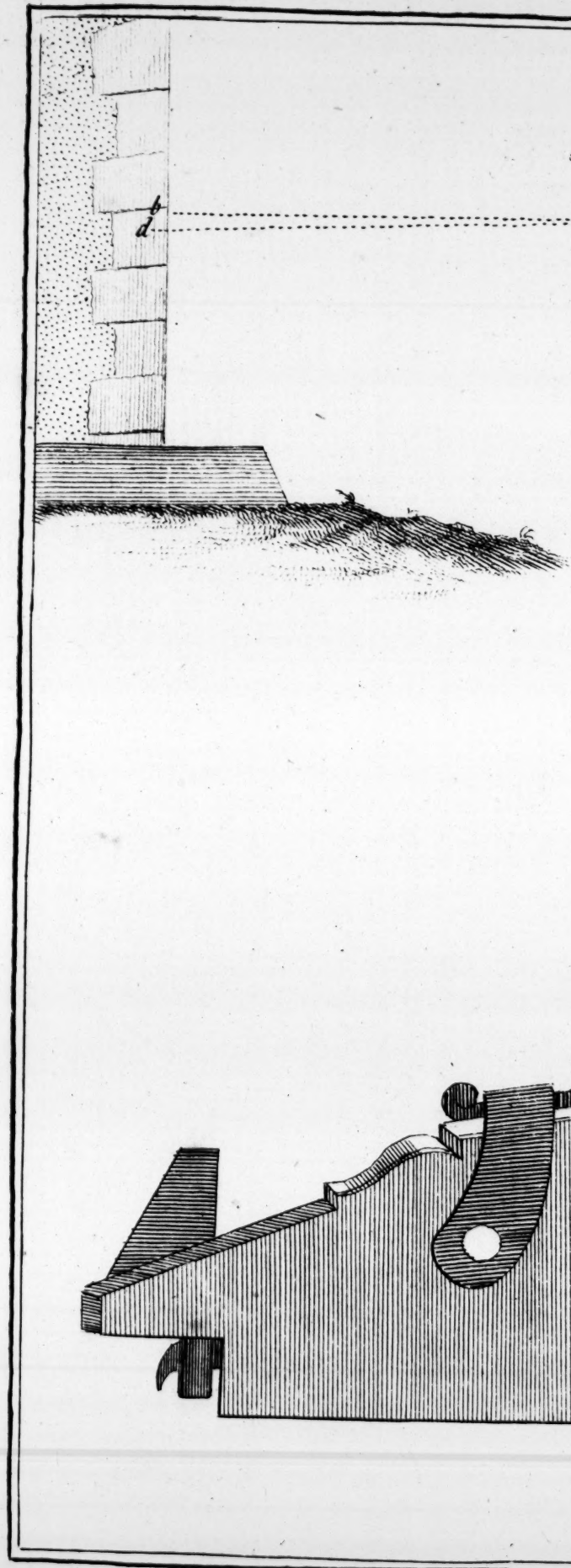
PL. V.
Fig. 2.

SECT. II. *Of the Carriage of the Mortar.*

THE mortar is placed upon a carriage, to facilitate the using it; the design of the carriage is to hold the mortar firmly in the situation it is put into, so that the explosion of the powder it is charged

charged with may not alter its direction. The carriage of the mortar has no wheels; for a mortar is not, as the cannon, removed from place to place on its carriage. Several sorts of carriages for mortars have been contrived; some have been made of iron, and some of brass; but we shall here treat of none but those commonly used, which are composed of two pieces of wood, more or less long and strong, according to the size of the mortar; these, as in cannon, are called *cheeks*, and joined by very thick transoms. In the middle of the upper side of the cheeks are two semicircular notches, to receive the trunnions; over each of these is placed a very strong band of iron, called the upper band, the middle of which is bent in a semicircle, to embrace the trunnions, and keep them fast to the cheeks of the carriage. The inward part of each notch, or hollow, is lined also with the like iron band, called from its situation the *under band*; these bands are made fast to the cheeks, by long iron pins of great strength; the upper band is sometimes fastened to the cheeks by another band of iron, that covers each of its extremities. The cheeks are strengthened before and behind with round bars of iron, which cross them from side to side, and serve to unite more firmly one part to the other, and bind the cheeks fast to the transoms; these are called pins. On the front of the cheeks, or carriage, are four iron pegs, or pins, set up perpendicularly; between these is placed a piece of wood, on which rests the belly of the mortar, or that part of it which contains its chamber. This piece of wood serves to support the mortar while it is fired, and is called the *pillow*. Instead of the iron pegs, it is sometimes secured in a groove, made on purpose, towards the extremity of the cheeks. When the mortar is to be elevated, and its inclination on the pillow lessened, the aiming wedge is introduced between the mortar and its pillow, almost in the same manner as in pointing







V.

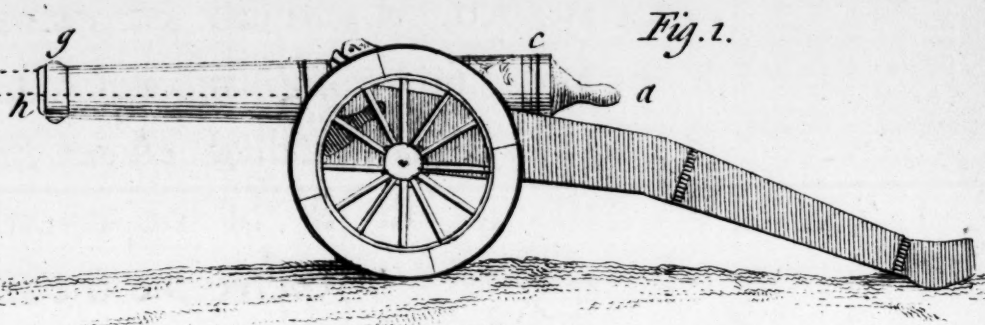


Fig. 3.

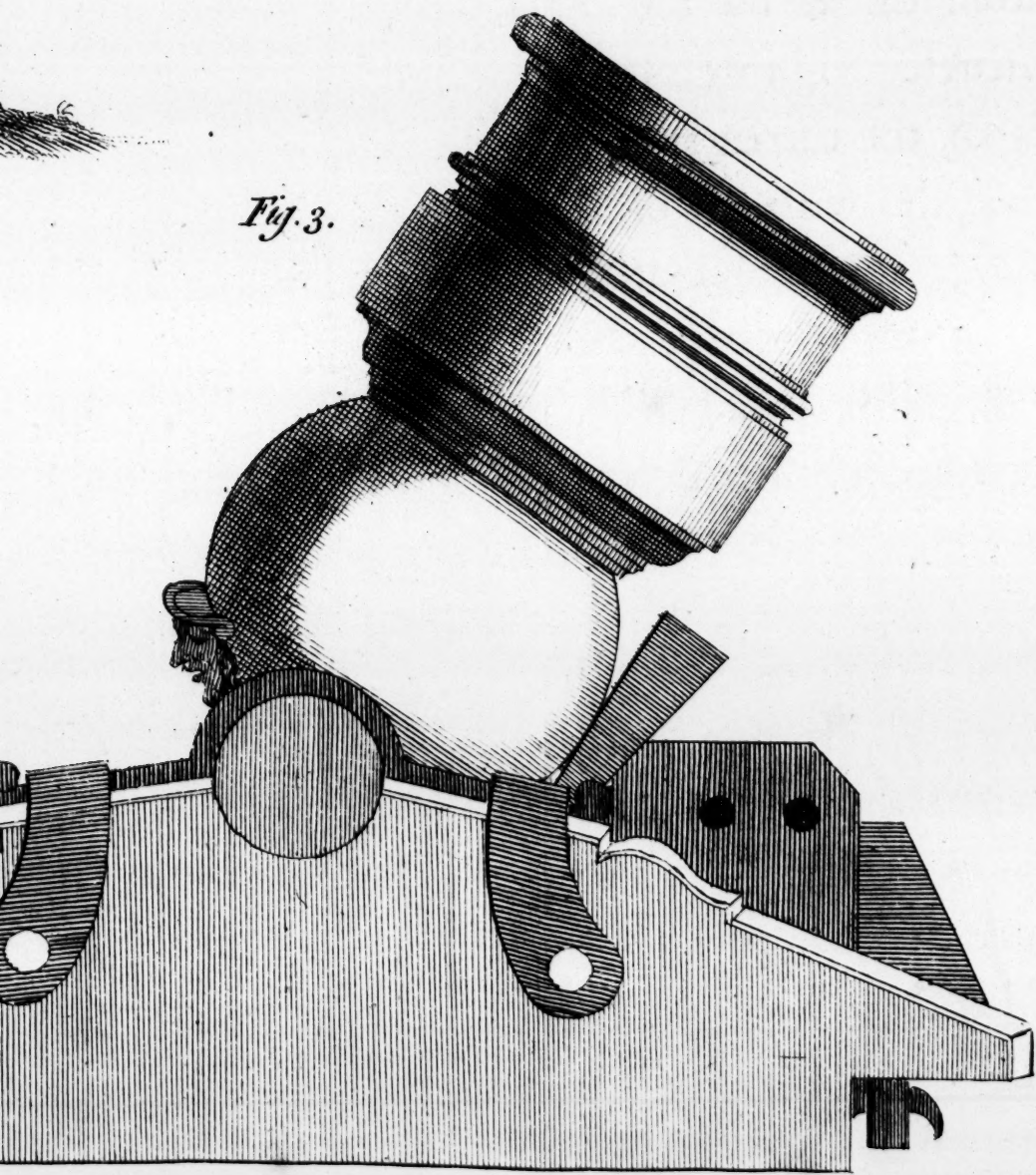
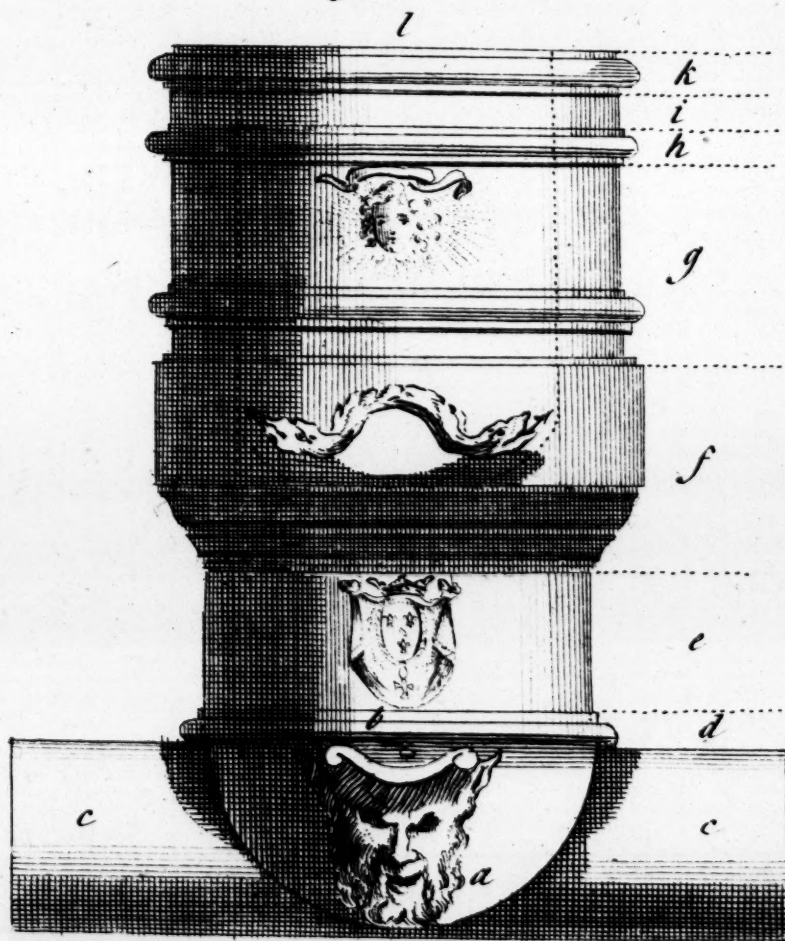


Fig. 2.



T. Jefferys sculp.

ARTICLE

OF THE

CONSTITUTION

OF THE

UNITED STATES

OF AMERICA

IN

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YEAR

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pointing cannon. For the mortar mounted on its carriage see Plate V. Fig. 3.

PL. V.
Fig. 3.

SECT. III. *Of the Position of a Mortar proper for firing a Bomb, and the line described by the Bomb during its motion.*

AS one of the effects of the bomb results from its weight, it is never discharged in the same manner as a ball from the cannon, that is, by directing or pointing the mortar at a certain object; but the mortar is a little inclined to the horizon, so that the bomb being thrown up obliquely, much in the same direction as a tennis ball struck by the racket, may fall upon the place intended; from whence it appears that a mortar has no point-blank range, or at least that no use is made of it.

The mortar being fixed in a situation oblique to the horizon, so as that the line ac , which passes through the middle of it longitudinally, being continued, would make an angle $b a d$, with the horizontal line ab , a bomb discharged in the direction of this continued line would deviate from it every instant of its motion by its weight, which inclines it towards the centre or superficies of the earth, and by this means it would describe a kind of curve line $a e b$, called by Geometricians a *parabola*.*

Weight, or gravity, always operates equally on a falling body; for
as.

* Our ingenious countryman, Mr Robins, by some very critical experiments, has demonstrated that the modern writers in the art of gunnery have been very much deceived in supposing the resistance of the air to be inconsiderable, and thence asserting that the tract of shot and shells of all kinds is in the curve of a parabola;

and that by this means all their determinations about the flight of shot, discharged with considerable degrees of celerity, are erroneous. See his *Principles of the Art of Gunnery*. But notwithstanding this observation, experienced gunners assert that their own principles are sufficient for practice.

as it always subsists in an equal degree, it must also always act with equal force, or, which is the same thing, produce always the same effect in the same time. So, if in the first instant of falling it communicates to a body a certain force capable of moving it a certain space, in every following instant it must communicate a force sufficient to move it the like space, and by this means the velocity of a falling body is every moment accelerated; for if it has one degree the first instant, it will have two the second, three the third, and so on. From whence it follows, that it must move different spaces every instant, and by that means describe the curve line just mentioned.

The line *a b* is called the extent of the range, or the amplitude of the parabola; and the line *a d* the line of projection, or direction of the bomb. *Pl. V. Fig. 3.*

PL. V.
Fig. 3.

SECT. IV. *Of the Method to be used, in order to throw a Bomb upon a Place proposed.*

TO make a bomb fall on a given place, two things must be considered.

First, The inclination, or position, which ought to be given to the mortar; and

Secondly, The quantity of powder it ought to be charged with.

We shall endeavour to give some idea of the manner of ascertaining both these particulars.

Supposing a mortar pointed vertically, and in this situation a bomb to be fired, it will describe a line nearly perpendicular to the ground on which the mortar is placed, I say *nearly*, because the mortar will always have some little motion, which will destroy the exact perpendicularity of the line described by the bomb; but,
ab-

abstracted from this, a bomb discharged vertically, or perpendicularly, would fall again into the mortar.

If the mortar be afterwards inclined more and more towards the horizon, the bomb will fall still further and further distant from the mortar, till the direction of the piece makes an angle of 45 degrees with the horizon; the more the mortar is inclined beyond or below this angle, the more the range of the bomb will diminish; all which is strictly demonstrated by geometry. But the following is a very simple manner of conceiving it, without having recourse to that science.

A bomb discharged in the direction of a line but little deviating from a vertical one, or a line perpendicular to the horizon, will fall at a little distance from the place the mortar stands upon; this requires no proof. A bomb thrown in the direction of a line, which makes a very acute angle with the horizon, will presently come to the ground by its weight, and consequently will not, any more than the other, fall at any considerable distance from the mortar.

This premised, it is easy to conceive that for a bomb to fall at the greatest distance from the mortar, it must be fired in the direction of a line at the greatest possible distance, as well from a vertical as horizontal line, or line level with the ground; this line is that which divides into two equal parts the angle form'd by the vertical and horizontal lines, which being a right angle, that is, an angle of 90 degrees, a bomb will be thrown to the greatest possible distance in the direction of a line making an angle of 45 degrees.

Above the angle of 45 degrees the range will diminish, because the bomb approaches the vertical line, and under this angle it will likewise diminish, because the bomb approaches the horizontal line.

By this it appears, that there are two angles, according to which a mortar may be inclined, to cause the bomb to fall on the same

G

place;

place; these are the angles equally distant from the line which cuts the quadrant into two equal parts; so that if (for example) a mortar be levelled at an angle of 30 degrees, the bomb will fall at the same distance, as if it had been levelled in an angle of 60 degrees, each of these angles being 15 degrees distant on this or that side from the middle of the quadrant, that is, from the angle of 45 degrees.

Knowing then that a mortar levelled in an angle of 45 degrees throws the bomb to the greatest distance, in order to throw a bomb to a given distance with a given charge of powder, it must also be certainly known that this quantity of powder is sufficient to communicate to the bomb all the force it will have need of; and this is the second thing to be considered.

A bomb must be fired with the quantity of powder given, in an angle of 45 degrees, and the distance found by trigonometry, or otherwise, from the place where the mortar stood; so that where the bomb falls, if this distance is greater than, or equal to the distance proposed, the quantity of powder with which the mortar was charged will be sufficient; if less, the quantity of powder must be increased; and when after some trials the proper charge is found, the mortar must be charged with that quantity, and the bomb will fall at the place intended.

After this the mortar must be fixed at such a degree of inclination as is thought proper, and in this situation it must be fired, and the place where the bomb falls observed; if the piece was levelled below 45 degrees, and the bomb does not fall so far distant as desired, the piece must be a little raised; if, on the contrary, it falls too far off, it must be a little more inclined; and by these essays the proper degree of inclination may be easily and speedily found.

If

If the mortar is levelled above 45 degrees, it must be more inclined, so as to make a more acute angle with the horizon, to increase the range of the bomb; and, on the contrary, raised nearer a perpendicular, to diminish it; all which are consequences drawn from what has been said on this subject.

When the inclination a mortar ought to have to throw a bomb to a given distance is found, it must be fixt in that direction; and the bombs fired with the quantity of powder, used in the essays or experiments just mentioned, will fall pretty near the place desired; I say pretty near, because it is very difficult always to charge a mortar exactly in the same manner, and a great number of circumstances happen which alter the flight of the bomb.

It must be observed,

First, that the greatest distance, to which a bomb can be thrown with the strongest charge, is little more than about 1800 or 2000 fathom.

Secondly, that though a mortar may be levelled, either so much above, or below, 45 degrees indifferently, to carry a bomb a given distance, yet when any building is to be destroyed, it must be levelled above 45 degrees, because the bomb rising to a greater height when fired according to a greater angle, falls with greater force, and by consequence will do more damage to the place on which it is thrown. But when a company of men are to be fired upon, the mortar must be levelled below 45 degrees, that the bomb may not have force enough to enter far into the ground, and that the splinters in the explosion may do more execution.

Thirdly, that what has been said of the flight of bombs is applicable also to cannon, the ball of which will go furthest when discharged in a direction nearest an angle of 45 degrees.

SECT. V. *Remark on the foregoing Method of throwing Bombs.*

THE method of finding the inclination or position of a mortar, as laid down above, is entirely mechanical; and the art of throwing bombs, which may be said to be now arrived at its highest perfection, would yet be very imperfect and trifling, if there were no other methods of finding this direction. But there are rules for doing this with much greater exactness, and by which the fittest direction of a mortar may be found at once, without making any previous essays. It is however true, that the exactness of the theory is scarce ever answered in practice.

For although the theory gives rules for throwing a bomb without trials upon a given place, yet experience does not always correspond with those rules, by reason of an infinite number of accidents, which cannot altogether be prevented. But these rules are not therefore useless, they answer the end proposed more speedily, and they also furnish principles and methods of perfecting practice. We shall not treat of those rules in this discourse, because they are founded upon several geometrical propositions, which are unknown to the greatest part of those for whose use this work is intended, and they may be found in most treatises of geometry and mechanics.

When bombs were first used, it was quite necessary to determine many things by essay, because principles and a more exact method were wanting. But it must appear very singular, at the time when M. *Blondell*, master of the mathematics to the Dauphin, and field-marshal and general of the king's forces, had composed an excellent treatise on the art of throwing bombs, that M. *St Remy*, who was not a stranger to that performance, should still apologize for essays.

“ It seems, says this author, alluding to the principles and theory of M. *Blondell*, that 'tis better steadily to follow those who are in the

“ the continual exercise of bombs, and who find by experience
 “ their method to be good, because experiments, and especially those
 “ made with gun-powder, are always of more weight than the most
 “ learned observations.”

There is a wide difference between the sentiments of the present day, and those of the time of M. *St Remy*, with respect to artillery. Practice has now all the attention which it merits, and at the same time the theory is not neglected; and hence it is that practice is brought to great perfection, and, as we may presume, will still be rendered more perfect. To this improvement the artillery schools established by the king will without doubt contribute; theory and practice go there hand in hand, and receive mutual assistance from each other. Nothing can exceed the order and establishment of these schools, and every thing may be hoped from the ability and merit of the officers placed at the head of them, and from the knowledge which there is in general among the gentlemen of the artillery.

SECT. VI. *Of the different Kinds of Mortars.*

There are mortars of different sizes, as there are cannon; some have cylindrical chambers, which they call mortars of *the old fashion*; some have spherical chambers, others chambers in the shape of a pear; these are in the *new manner*; and, lastly, there are others with chambers shaped like the frustum of a cone.

The mouths of mortars are from 6 to 18 inches diameter, the chambers are bigger or less according to the size of the piece, and they contain from 2 to 12, and even to 18 pounds of powder. In *Plate VI.* and *VII.* may be seen different mortars with their chambers. PL. VI.
VII.

The mortar *a* is 4 feet 4 inches high, all its cavity is marked by a pricked line; the narrowest part of this cavity, which lies PL. VI.
Fig. 2.
nearest

nearest to the breech, is the chamber of this mortar, and is in the shape of a pear; the mouth or aperture of this chamber begins at the moulding of the renfort, and is 5 inches and an half diameter; the chamber is 13 inches long, and 7 and an half diameter in the middle; it contains 12 pounds of powder. The trunnions of this piece are 32 inches from point to point, and 9 in diameter: the bomb it discharges is 17 inches 10 lines diameter, and its thickness, which is included in this diameter, is every where 2 inches, except the part on which it rests in the piece, which is 10 lines thicker; it contains about 30 pounds of powder, and it weighs 520 pounds when charged.

PL. VI.
Fig. 3.

The mortar *b* has a spherical chamber, which contains 18 pounds of powder; the bore of this mortar is 12 inches and an half diameter at its mouth, and its length is 18 inches and an half; its chamber is 9 inches and 7 lines diameter, its aperture, or neck communicating with the upper cavity, or bore, 6 inches diameter, and 4 inches long; the trunnions of this piece are from point to point 31 inches and an half, and 8 inches diameter. Its height is in all 3 foot 5 inches one third; the bomb it carries is 11 inches diameter, it contains 15 pounds of powder, and weighs about 130 pounds.

PL. VI.
Fig. 4.

Figure 4. Plate VI. is the section, or profile of another spherically chamber'd mortar, the height of which is in the whole 3 foot 2 inches, and the length of its trunnions from point to point, is 30 inches, and their diameter is seven.

This figure serves chiefly to show the little chamber *c* (3) of the

(3) It may also serve to show the thickness and dimension of every part of the mortar, if the length of the trunnions *a b* be taken for a scale, and

divided into 30 equal parts, remembering that this length is 30 inches, the several parts of which are used to measure those of the mortar.

There

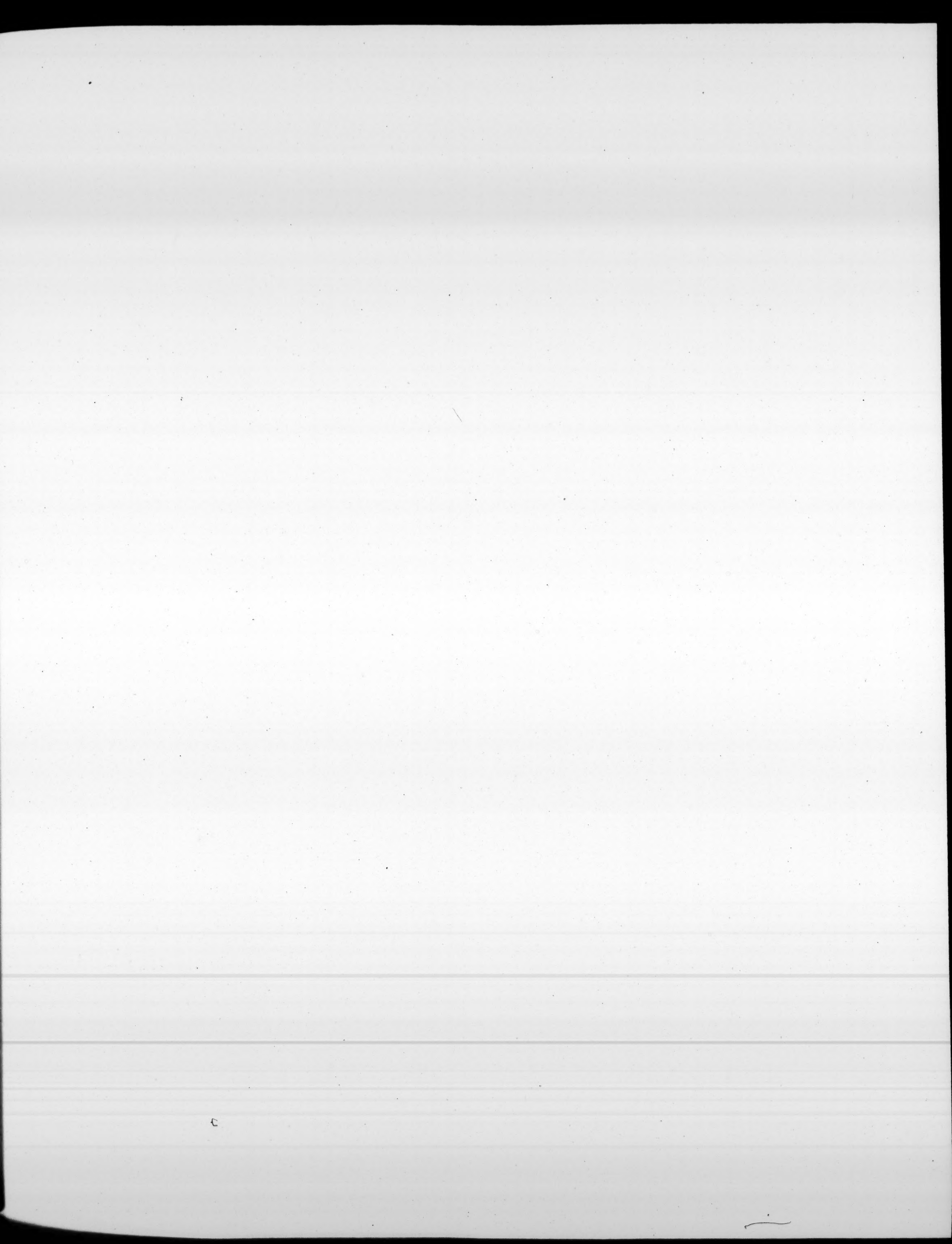
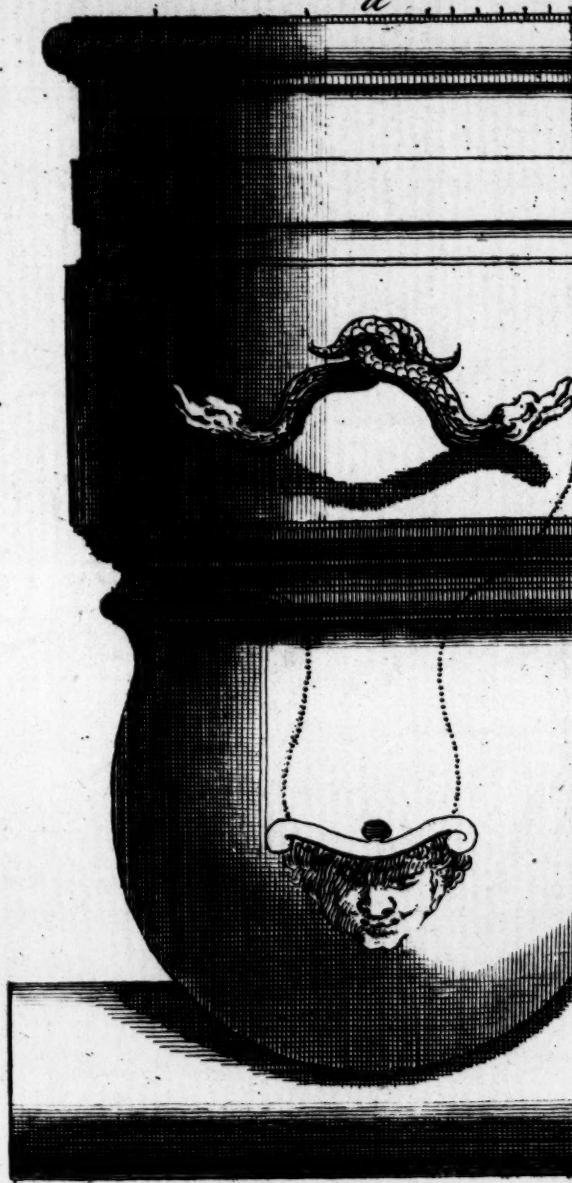


Fig. 2.

a





VI.

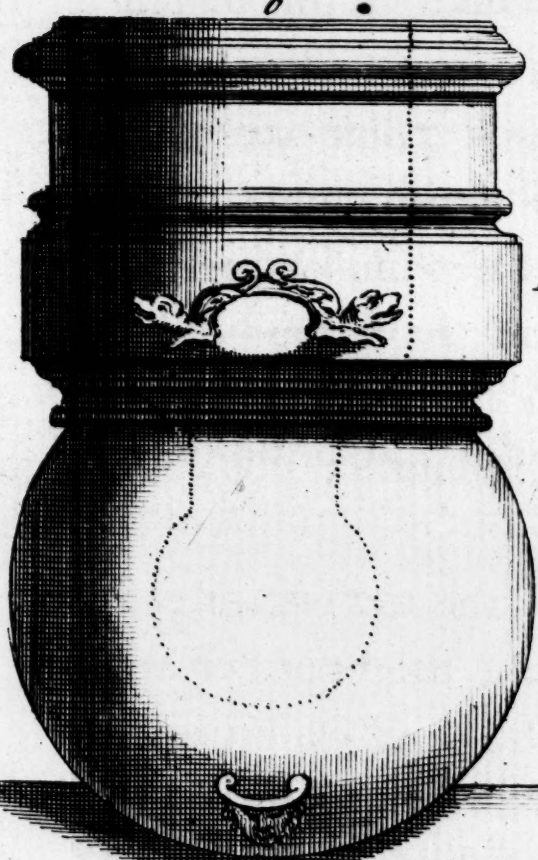
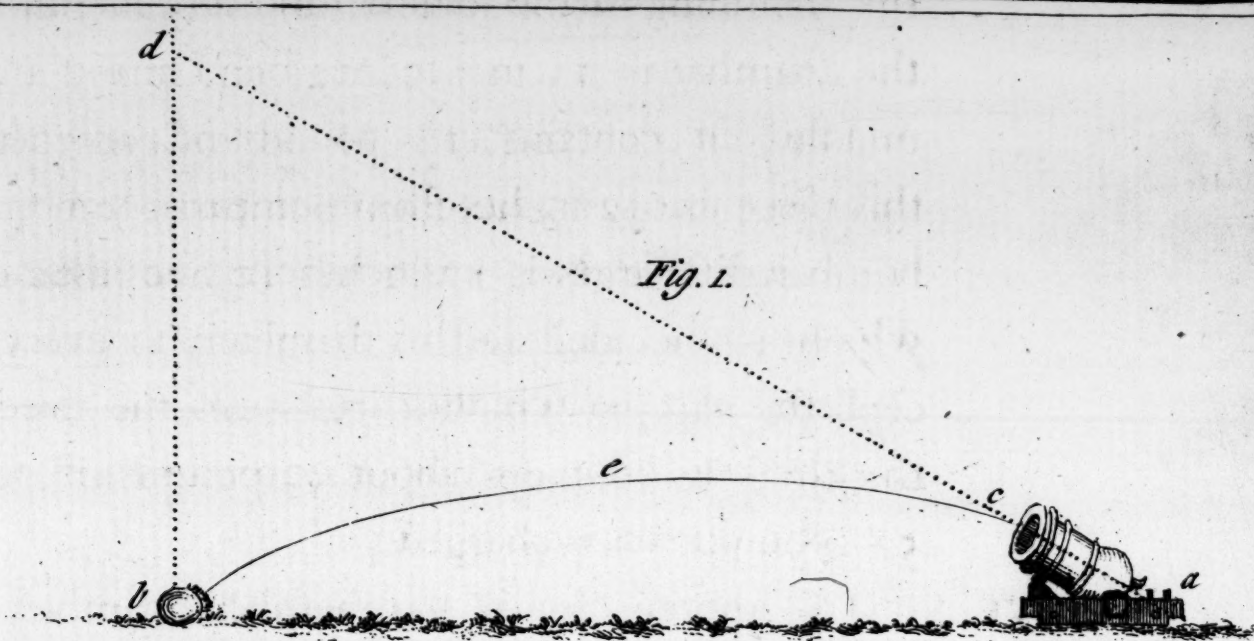


Fig. 3.

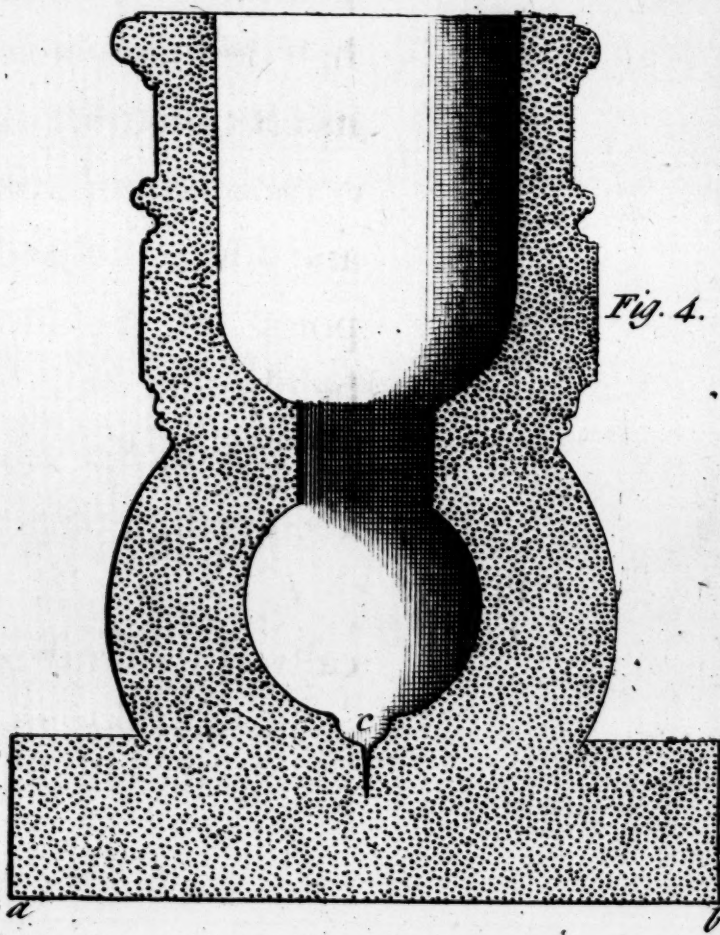


Fig. 4.

T. Jefferys sculp.

the depth of one inch, or thereabout, and two inches in diameter, which is made at the bottom of the bore of the mortar, much in the same manner as in the pieces of cannon called 24 and 16 pounders; the pipe of the touch-hole terminates in the bottom of this little chamber, and is bored in a piece of copper, as those of cannon, in the shape of the frustum of a cone inverted. This metal is about an inch and an half diameter in its upper part, and two inches and an half at the bottom; its use is the same as in cannon, to resist the effort of the powder with greater force than the metal of the piece, and by consequence preserve the touch-hole.

Fig. 1, and 2 in Plate VII. represent two other mortars. The first *e* is a side view of a cylindrically chambered mortar; it throws a bomb of 11 inches and two thirds, its bore is 12 inches diameter at the mouth, and 18 deep, its chamber is 9 inches and an half long, and 5 inches and a quarter diameter, and contains 6 pounds of powder; the trunnions of this mortar are 28 inches long, and 8 in diameter.

PL. VII.
Fig. 1.

The second figure *f* in the same *Plate VII.* is a spherically chambered mortar, which, as well as the preceding, throws a bomb of 11 inches two thirds. It is 12 inches and an half diameter at its opening or mouth, not including the thickness of the metal. The depth of its bore is 18 inches, its chamber is 8 inches two thirds long, and seven in diameter; it contains 8 pounds of powder,

Fig. 2.

There is no scale on the plates where these mortars, and the greatest part of the other figures referred to in this treatise are represented, because they are formed by different scales; but as they are drawn in the exact proportion each part ought to bear to the others, any person desirous of knowing these proportions particularly, may take for a scale the

length of the trunnion, or any other lines, of which the exact length may be found in this work, and divide it into the number of feet or inches, which ought to be contained in it; and they will have by this means a scale for each mortar, or other piece, by which they may know with considerable exactness the dimensions of all their parts.

powder, its trunnions are thirty inches long from one end to the other, and seven inches diameter; the entire height of this piece is three feet.

PL. VII.
Fig. 5.

Fig. 5. Plate VII. represents a small mortar, used only for proving powder. We shall give all the proportions of this piece, when we come to describe the manner of making that proof.

SECT. VII. *Remark upon the Chambers of Mortars,*

THE spherical and pear-shaped chambers are esteemed better for mortars than the cylindrical, not having the same inconveniency as in cannon, because in mortars they are more easily cleaned. These sort of mortars are also more used, at present, than those with cylindrical chambers.

SECT. VIII. *Of Bombs, and the Quantity of Powder with which they ought to be charged.*

HITHERTO we have spoken of the bomb only as a sort of bullet; it is now necessary to be more particular, that the reader may be more minutely acquainted with it.

PL. VII.
Fig. 3, 4.

The *figures m* and *n* may serve for this purpose. The first *m* shews a bomb as it appears to the eye, the second *n* represents it in section, or in profile, and consequently shows its thickness; the parts *a* and *b* of the bomb *m* are its handles, or the part by which it is lifted up; *f* is the touch-hole, or aperture through which the powder is poured in to charge it.

“ Experience shows (as M. *Belidor* tells us, in his *Bombardier François*) “ that 15 pounds of powder ought to be put into a
“ bomb of 12 inches, which weighs when charged about 145
“ pounds: that a bomb of 8 inches requires 4 pounds, weighing
“ when

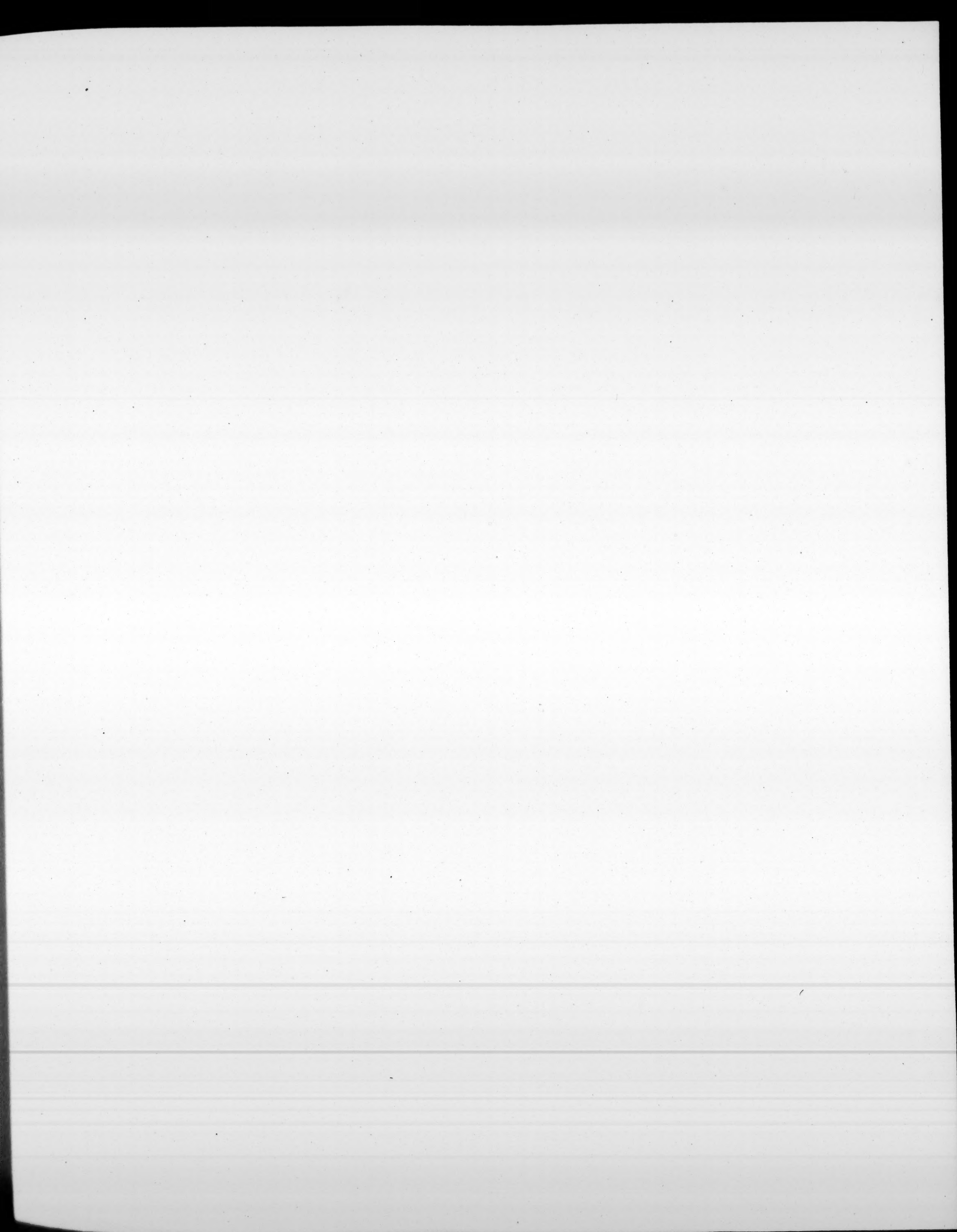


Fig. 5.

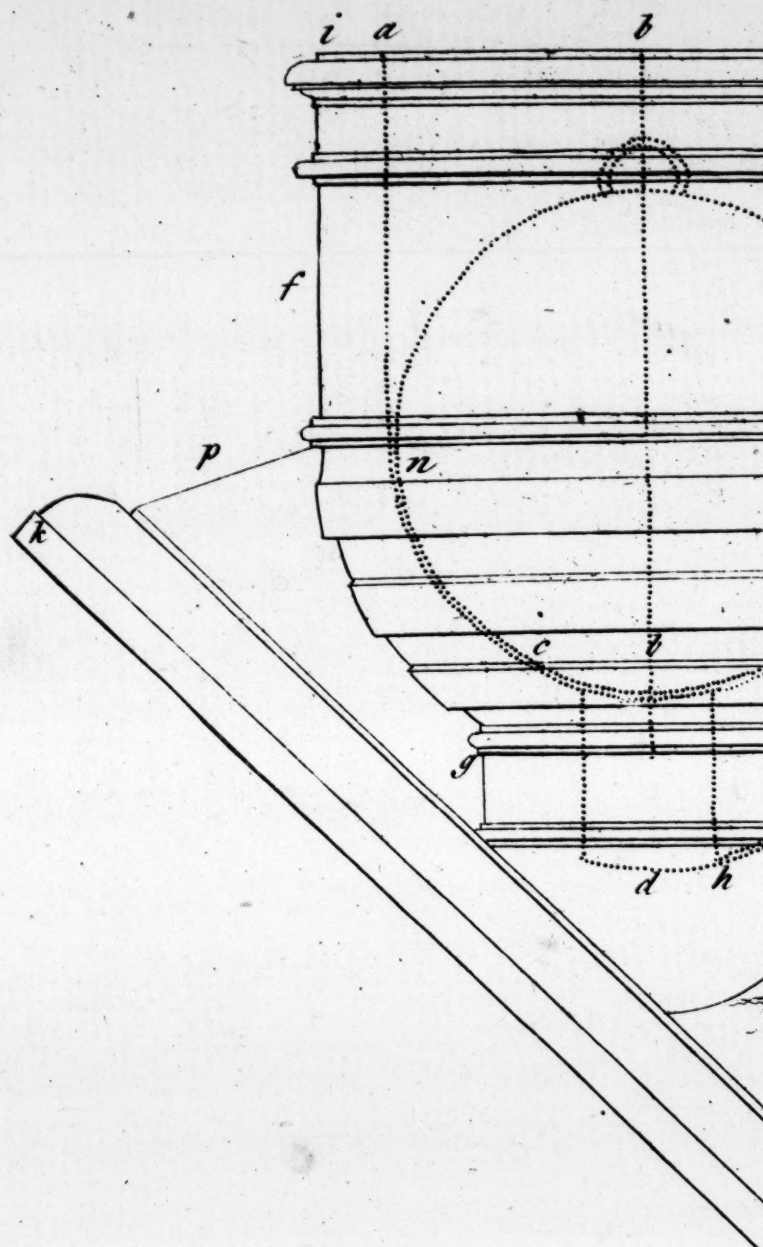




Fig. 2.
f

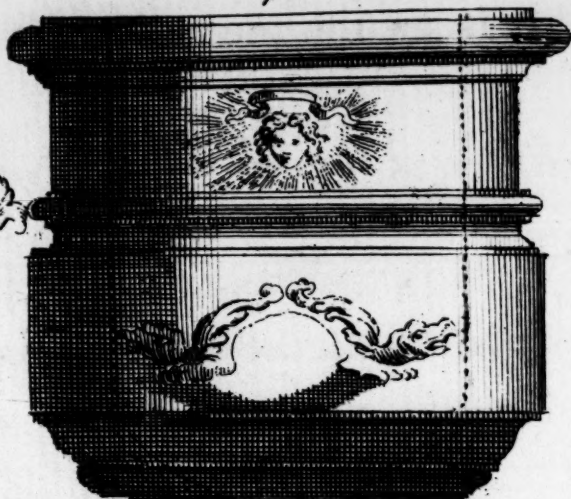


Fig. 1.
e

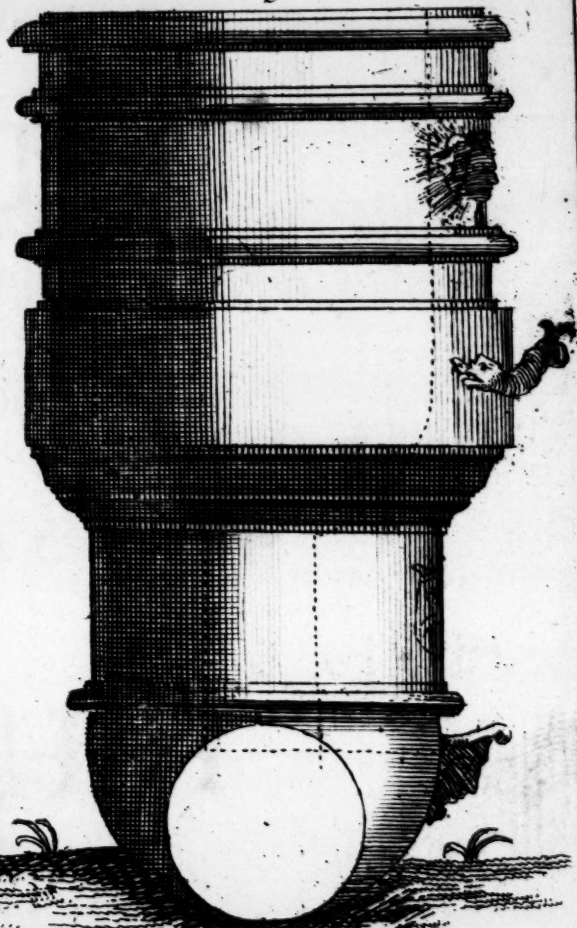


Fig. 4.

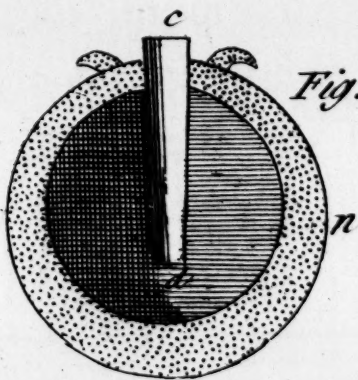
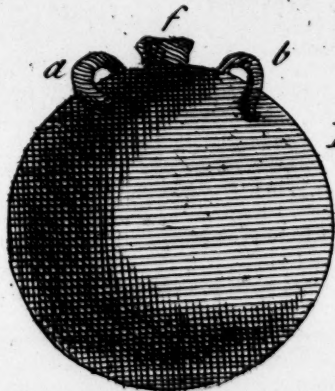
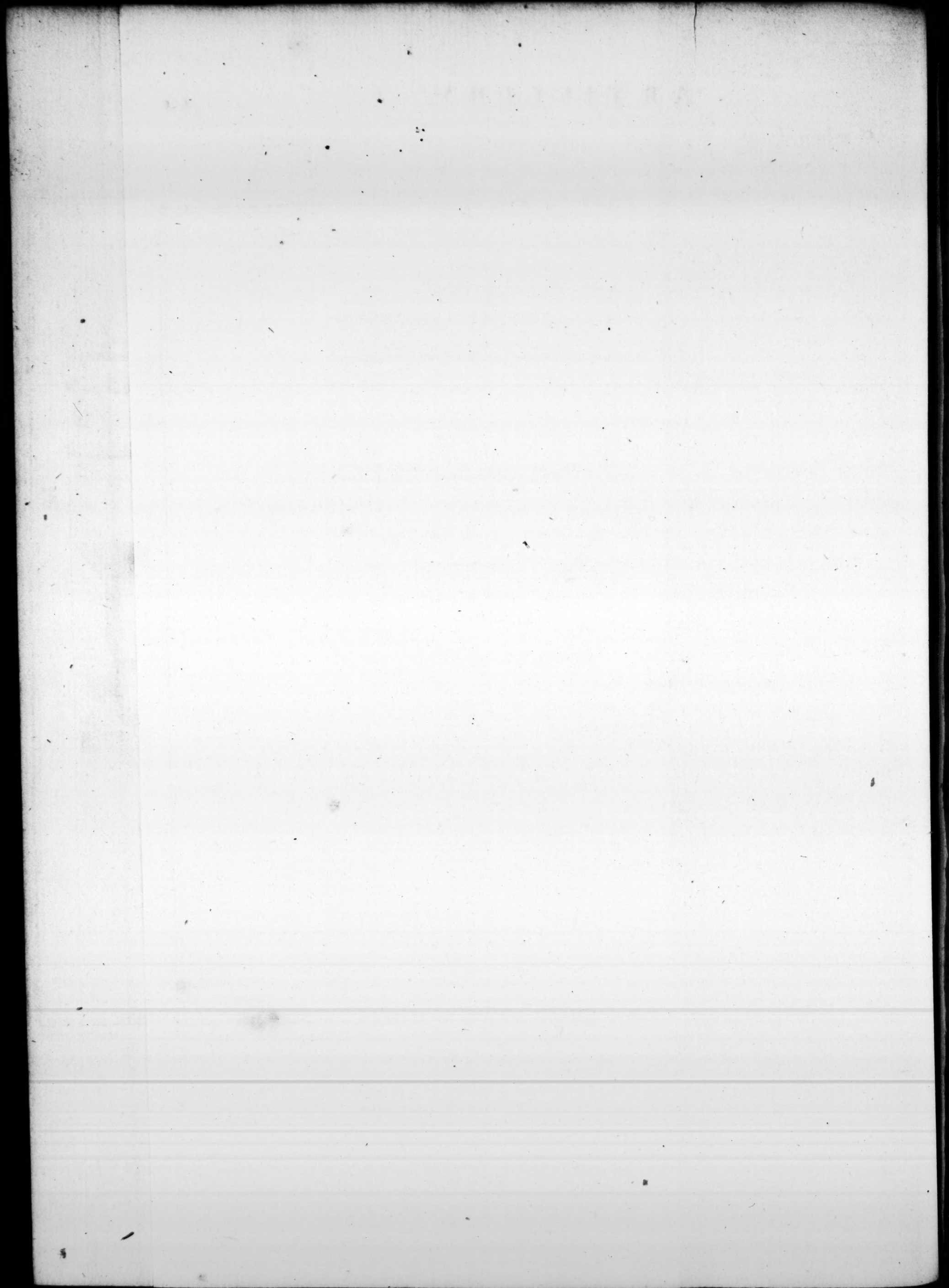


Fig. 3.





“ when charged about 40 pounds; that one of 6 inches requires
 “ 3 pounds, and weighs when charged a little more than 23
 “ pounds: And, lastly, that 30 pounds of powder are required
 “ for a bomb of 17 inches 10 lines diameter, which weighs, when
 “ charged, about 520 pounds.”

But later experiments prove, that the same bombs, charged with a much less quantity of powder, will produce the same effect. M. *Belidor* himself has reduced this quantity to 2 pounds and an half, or 3 pounds for a bomb 12 inches, and one pound for a bomb of 8.

It is evident that the design of the powder, with which a bomb is charged, is to make it burst, and that if it bursts with a quantity of powder less than it is commonly charged with, that quantity is sufficient, and that all above it is absolutely lost.

There is however one particular to be observed, which is, that when bombs are intended to fire the buildings on which they are thrown, the larger the charge, the better they succeed; but on all other occasions, the quantity of powder, more than sufficient to burst the bomb, cannot produce any advantageous effect.

It appears by *Figure n*: That the lower part of the bomb is thickest, which is contriv'd that the bomb, being heavier on that side, may be sure to fall upon it, and never upon the fuse *c d*, of which we shall speak presently; this heavy under part is called the breech of the bomb. The diameter of a bomb ought at least to be 5 or 6 lines less than the bore of the mortar, from which it is to be discharged.

PL. VII.
Fig. 4.

SECT. IX. *Of the Fuses of Bombs.*

PL. VII. **T**HE fuse of the bomb is represented by *cd* in *Figure n.* It is a kind of little frustum of a cone, concave within, made of linden, willow, or some other very dry wood, filled with a composition of the best powder, sulphur and salt-petre. The bomb being charged, this fuse is inserted in the cavity through the touch-hole, and when fired, communicates the fire to the powder with which the bomb is charged; the wood of the fuse, before it is charged, is called the *Ampoulette*.

According to a regulation made in 1713, for settling the proportion of the fuses to the bombs, those for bombs of 12 inches diameter ought to be 8 inches long, and 20 lines (or 12ths of an inch) diameter at the big end, 14 at the small, and 5 in their cavity or bore.

The fuses for bombs are charged with great care, that nothing may prevent or stop their communicating the fire to the powder in the centre of the bomb; they are driven and fixt into the bomb, so that only about an inch and an half comes out beyond the touch-hole.

These fuses are also charged long before there is occasion to use them; and that the composition they are filled with may not fall out, or spoil by growing damp or wet, the two ends are covered with a composition of tallow, mixt either with bees-wax or pitch. When the fuse is to be put into the bomb, care is taken to open the little end, or cut it off; as to the great end, it is never opened till the bomb is in the mortar, and just going to be fired.

SECT. X. *Of the Instruments necessary to charge Mortars, and of the manner of charging them.*

TO charge a mortar (as in charging cannon) many instruments are necessary.

The principal are, a rammer of the same diameter as the piece, to ram in and beat down the wadding and turf which cover the powder; an iron scraper, to clean the bore and chamber of the mortar, and a little spoon to clean more particularly the powder chamber; a wooden knife, of about a foot long, to force the earth close in round the sides of the bomb; there is need also of priming-irons, aiming wedges, and two lint-stocks.

The officer who directs the charging of the mortar, having ascertained the proper quantity of powder, causes it to be put into the chamber of the mortar, and then to be covered with a wad, well beat down with the rammer. Over these are put two or three shovel-fuls of earth, which are also well beat or rammed down; after which the bomb is placed upon this earth, as near the middle of the mortar as possible, with the fuse, or touch-hole, uppermost; more earth is then put in, and pressed down close all round the bomb, with the wooden knife just mentioned, so as to keep the bomb firm in the situation it is placed in. All this being done, the officer points the mortar, that is, gives it the inclination necessary to carry the bomb to the place design'd. When the mortar is thus fixed, the fuse is opened, the picker is also passed into the touch-hole of the mortar to clear it, and it is then primed with the finest powder. This done, two soldiers, taking each one of the lint-stocks, the first lights the fuse, and the other fires the mortar. The bomb, thrown out by the explosion of the powder,

is carried to the place intended, and the fuse, which ought to be exhausted at the moment of the bomb's falling, sets fire to the powder it is charged with; this, immediately, by its explosion, bursts the bomb into splinters, which are thrown off circularly round the point the bomb falls upon, and do considerable damage on every side.

SECT. XI. *Remark.*

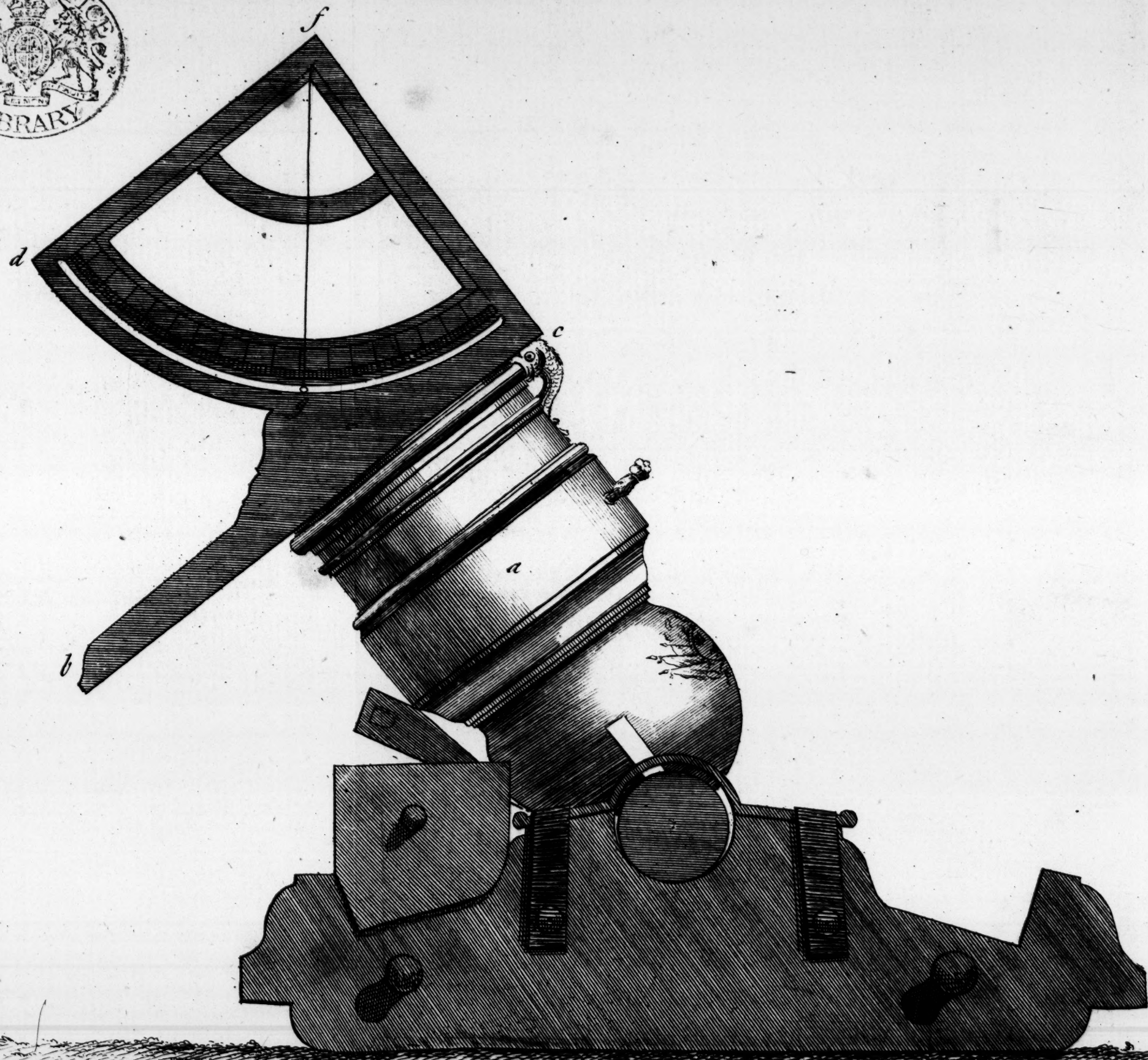
IF the fuse sets fire to the bomb before it falls on the place intended, the bomb will burst in the air, and may do as much mischief among those who fired the mortar, as those against whom it was discharged. To prevent this inconveniency, it is so contrived, that the fuse (the time of its burning out being pretty exactly known) shall not fire the bomb till the moment of its fall on the place against which it is thrown. To effect this (as the fuse will last at least as long as the time the bomb is in going its greatest possible range) when a bomb is thrown to a great distance, the fuse and the mortars are fired at the same time, and when the bomb has not far to go, part of the fuse is suffered to burn out before the mortar is discharged.

SECT. XII. *Of the manner of levelling, or pointing a Mortar, or giving it a proper degree of Inclination.*

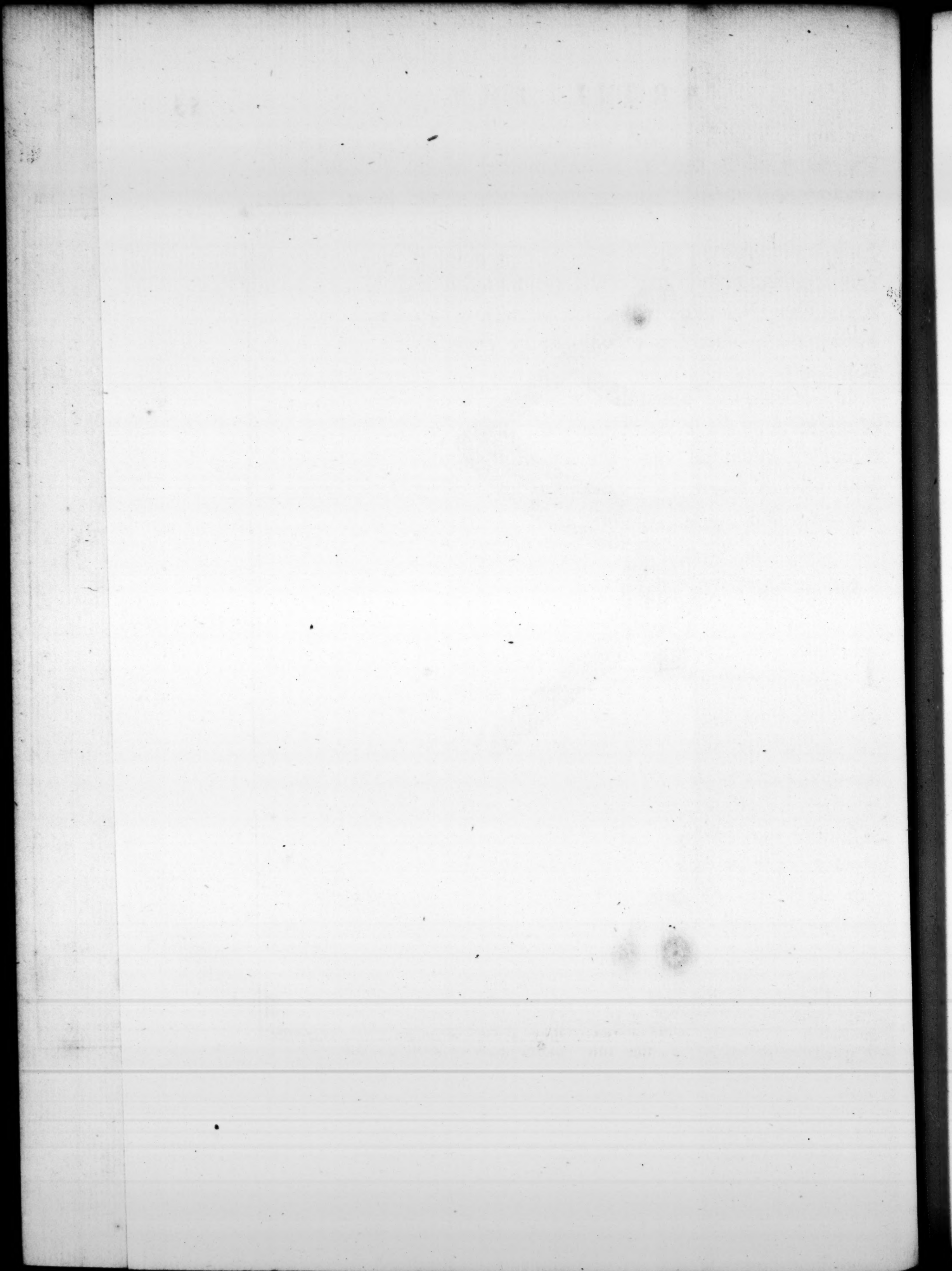
WE shall now treat of the pointing a mortar, the method of which is as follows.

PL. VIII: Let *a* be a mortar mounted on its carriage, which is to be levelled, so as to make (for instance) an angle of 50 degrees with the ho-





T. Jefferys sculp.



horizon. A quadrant cd (4), divided into degrees, is placed on the mouth of the mortar, in such manner as that the side of the quadrant cf shall be parallel to the bore of the piece. At the centre of this quadrant f a thread is fastened, at the end of which hangs a plummet g ; the mortar is to be raised till this thread fg falls upon the 50th degree of the quadrant, counting from the point d , and then the mortar will make an angle of 50 degrees with the horizon; any other inclination may be given by the same means at pleasure.

It is evident that the arch dg is the measure of the inclination of the mortar; for if the mortar were parallel to the horizon, the thread fg would fall upon the side of the quadrant fd ; now in proportion as the mortar is raised, the thread will descend towards c ; therefore, &c.

SECT. XIII. *Of Bombs fired by way of the Ricochet.*

IN treating on the firing of cannon, we observed, that Monf. the marshal *de Vauban* was the contriver of the ricochet, an invention which may be said to render the defences of the enemy useless, and which has brought the attack of places to great perfection. But this has been almost wholly confined to cannon, unless the name *ricochet* be allowed to the bombs thrown with the *obus* or *barwitzer*, (a kind of mortar which will be treated of in its place) which strictly corresponds in effect with the ricochet, since the use of them is to roll in shells among bodies of men, and there do great execution. But they do not appear to have been hitherto used in the attack
of

(4) To point a mortar easily and exactly, a quadrant must be used, as it is represented, *Plate VIII.* with a rule, cb , parallel to the radius fd ; this rule being placed, diametrically, upon the mouth of the mortar, the line fg will show at once the angle fg , which the mortar makes with the horizon.

of places; the governors of the school of artillery at *Strasburg*, judging however that bombs fired by way of ricochet might be used against fortifications with great advantage, made several experiments on the subject in 1723, which are related by M. *Belidor* in his *Bombardier François*, from which the following account is extracted.

“To fire bombs in ricochet, mortars of 8 inches diameter are made use of, mounted upon cannon carriages. The batteries erected for this purpose are placed upon the continuation of the branches of the covered way, because bombs there do so great execution, that it is scarce possible the troops should keep possession of it. They break palisadoes, barrs, and intrenchments, which are made in the reentrant or entering place of arms, and create much more disorder than bullets; for they are not only bigger and heavier, but, after making many bounds, burst where they stop, without entering the ground, and their splinters are always fatal. Besides, these mortars may be used with greater expedition than cannon; for there is nothing to do, but to put the powder into the chamber, the bomb upon it, and fire; and as this may be done in 3 or 4 minutes, a battery of two mortars, used in this manner, will throw thirty, or forty, bombs in an hour. I leave any one to judge (adds M. *Belidor*) if a covered way was flanked by such batteries, what garrison could maintain their ground, what advantage the besiegers would there have, in making a vigorous attack, and with how much facility they might advance their works.

“As the bombs must be prevented from entering the ground when they fall, because they would not then roll or bound, the mortars ought never to be pointed above 12 degrees; but any angle may be taken between 8 and 12, which is found most convenient, with respect to the charge the mortar is fired with, and the distance of the place where the bomb is intended to begin to bound. The

expe-

experiments made at *Strasburg* may serve as rules on this subject, and are as follow.

“ A battery was erected 70 fathom from the faillant angle of the covered way of the half moon of the polygon belonging to this school; a mortar, pointed at 9 degrees above the horizontal line, and charged with three quarters of a pound of powder, threw the bombs upon the glacis at 2, 4, 6, 8, fathom from the parapet of the covered way, where rising with a bound, they went forward, falling first in the branch between the two traverses, and then in the reentrant place of arms against a small intrenchment which had been thrown up there on this occasion.

“ The piece was afterwards pointed at 10 degrees, with the same charge, and after 5 or 6 times firing in this manner, it was observed that the bombs fell in the place of arms of the faillant angle, and there rising with a bound, fell again, as in the former, in the branch between the two traverses, and then into the reentrant place of arms. The mortar was at last pointed at 11 degrees, and still fired with the same charge; after discharging it 5 or 6 times, it was observed that the bomb still fell in the branch between the two traverses, and rising, went from thence over the covered way. From all this it was concluded, that the most advantageous manner of firing by way of ricochet is, when the mortar is so levelled that the bombs may fall on the crown of the covered way, or the faillant place of arms, by which means they never fail of producing considerable effects.

“ In order to try if the fuse would not be extinguished, either by the fall of the bomb, or its rolling in the ricochet, several were discharged with the fuse lighted, all which succeeded, the fuse burning till it was quite consumed.



Of Pedreros, or Mortars for discharging of Stones.

HITHERTO we have only treated on mortars used for throwing bombs; there are however others for the discharging stones.

PL. IX.
Fig. 1.

This mortar is represented by *Figure 1. Plate IX.*

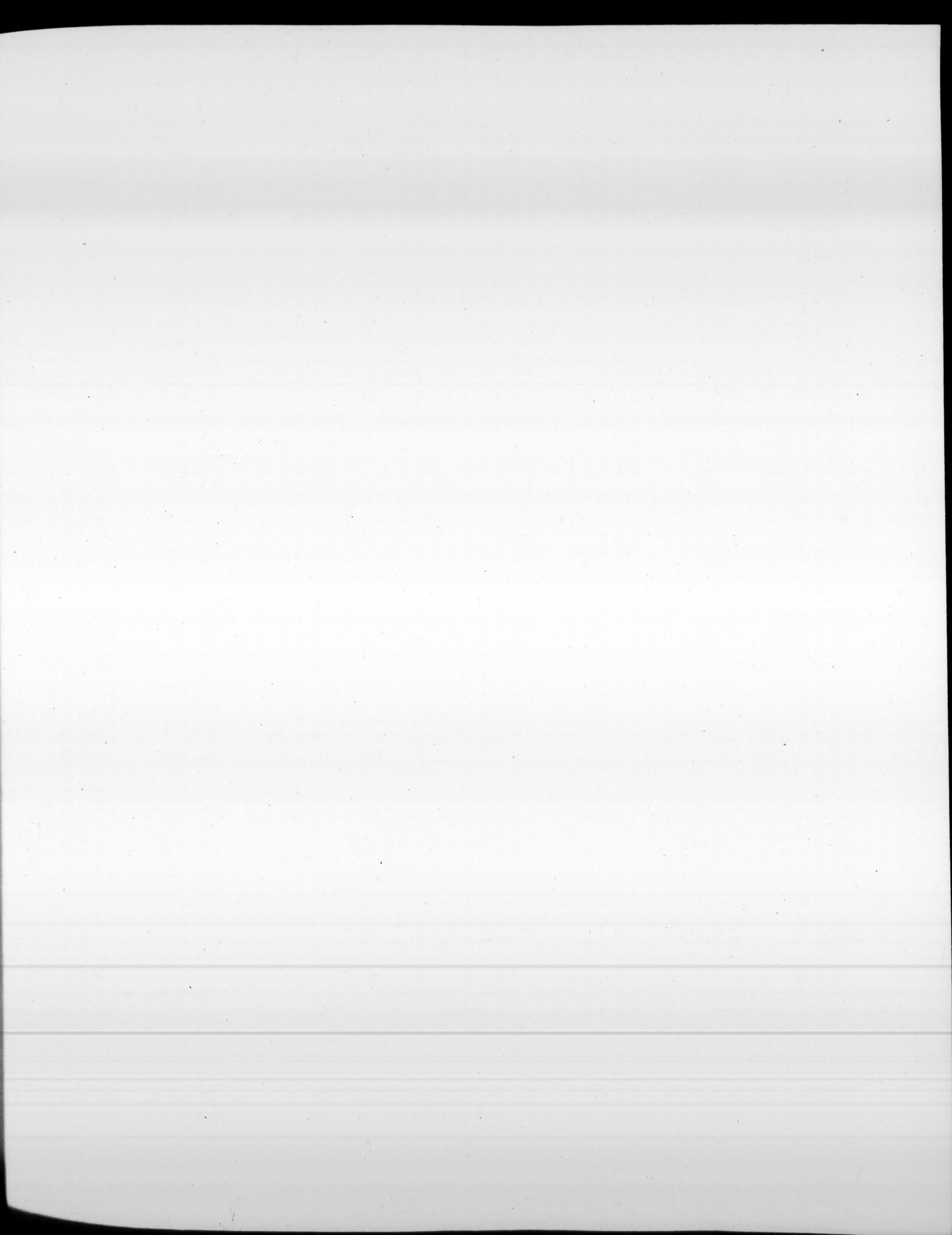
- a* Are the trunnions.
- b* The muzzle, with the touch-hole upon the breech.
- c* The renfort with its mouldings.
- d* The belly.
- e* The platband of the renfort of the chace, with its mouldings.
- f* The rings, or renforts on the chace.
- g* The rim.
- h* The mouth.
- i* The handle.

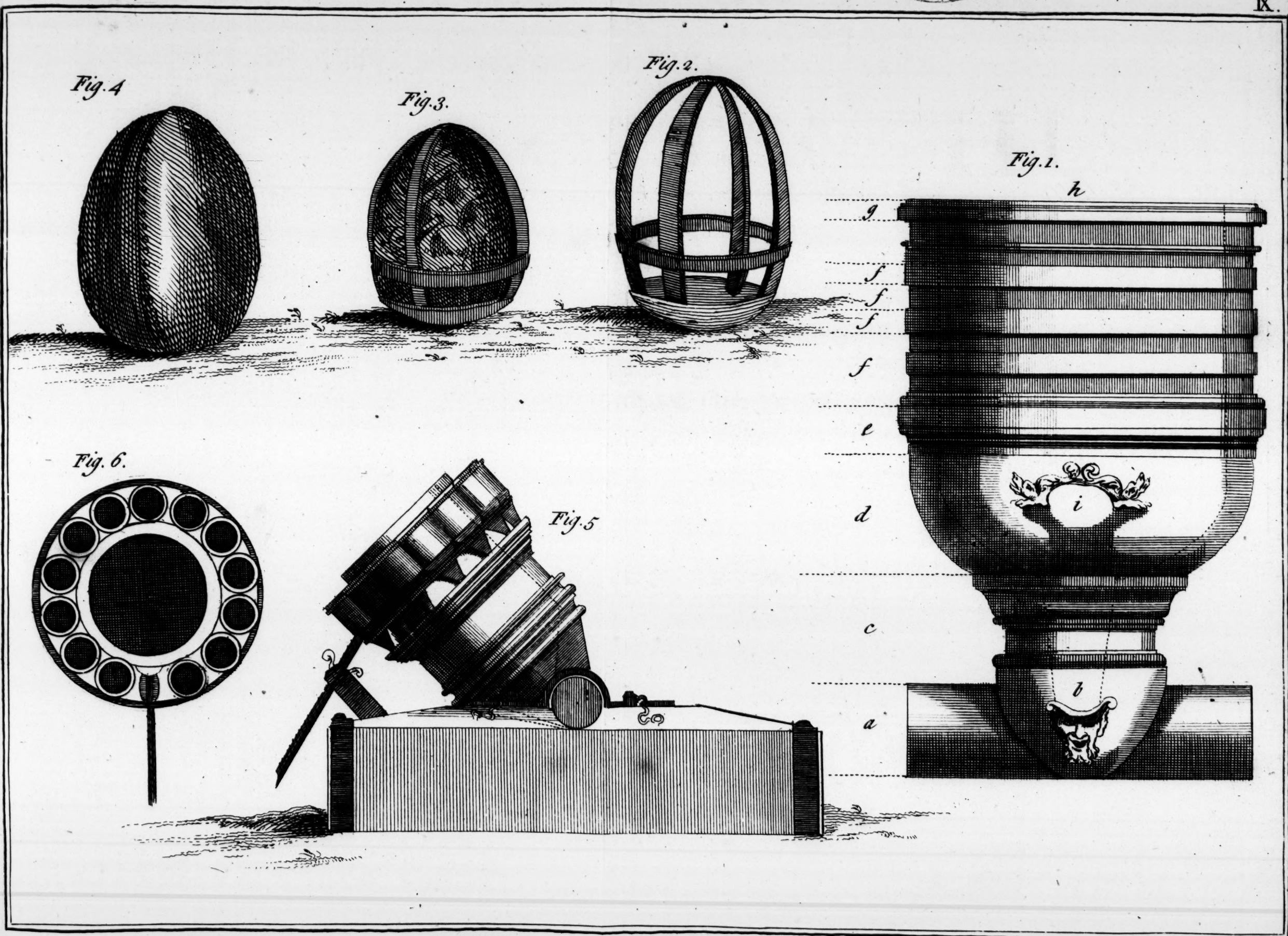
The bore of this piece is marked by the pricked lines from the rim to the bottom of the belly.

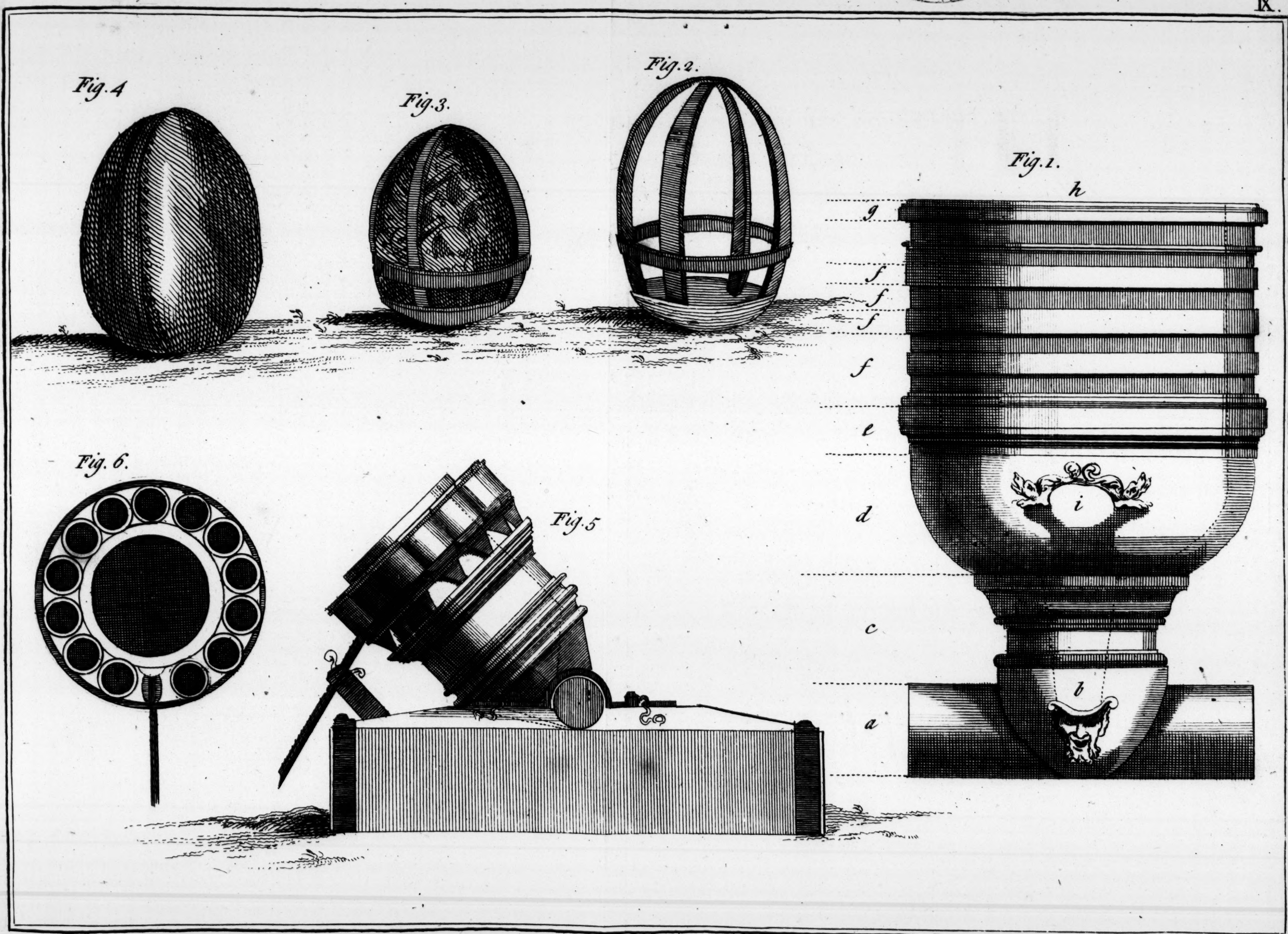
The chamber, by the pricked line from the belly to the touch-hole.

The range of this piece, when charged with two pound and an half of powder, is not less than 150 fathoms.

Its mouth is about 15 inches diameter, the depth of the bore one foot 7 inches, and that of its chamber about 8 or 9 inches; this is shaped like the frustum of a cone, four inches diameter at the top, and 2 and an half at the bottom; the length of its trunnions is 20 inches, and their diameter 5 inches and an half; its touch-







touch-hole comes precisely to the bottom of the chamber, and is bored in a piece of copper, as those of cannon and mortars; this piece weighs about 1000 pounds.

SECT. II. *Of the Carriage of the Pedrero.*

THE Pedrero is placed on a carriage like that of a mortar, but as the shock is not so great, the carriage need not be so strong. The carriage of the Pedrero consists only of one strong piece of wood, about 5 foot long, 18 or 20 inches wide, and about 12 or 14 thick. In the middle of this piece of wood is a groove, or intail, for the reception of the trunnions of the Pedrero; on the sides of the groove are two circular cramps or hold-fasts of iron, which bend over the trunnions, to keep the piece firm in its carriage; on each side of the carriage, two castors, or small wheels, are let into the wood, by which the carriage is moved backward and forward,

SECT. III. *Of the manner of charging the Pedrero.*

THE Pedrero is charged in the same manner as the mortar; first a quantity of powder is put in, which ought to be sufficient to fill the chamber; this powder is covered with hay and earth, beat down with the rammer, upon which is placed a proper quantity of stones or pebbles. Some officers cause these stones to be inclosed in a basket made for that purpose, but this practice is not general.

There have been some Pedreros made in such a manner as to be charged at the breech, but these are entirely disused at present.

The effect of the Pedrero is very considerable, and the showers of stones thrown from it like hail do great execution, and create much disorder.

To give these pieces their utmost effect, they should not be above 150 paces from the place where their contents are intended to fall. Small bombs are sometimes mixt among these pebbles, which still increase the effect.

CHAP. V.

Of GRENADES.

THE Grenado is a kind of little bomb, of the same diameter as a four-pound bullet, it weighs about two pounds, and is charged with four or five ounces of powder.

Grenadoes are thrown by the hand of the soldiers, called from hence *Grenadiers*; they have a touch-hole in the same manner as a bomb, and a fuse of the same composition. The soldier fires the fuse with a match, and throws the grenado as he is directed; the powder in the grenado taking fire, bursts it into splinters, which kill or maim whomsoever they reach; a soldier can scarce throw a grenado further than 15 or 16 fathom at most.

There are other grenadoes, which are not thrown (from the hand) but rolled into ditches, trenches, or other places where it is expedient to make use of them; these are properly a sort of bomb, and are from 6 to 3 inches diameter.

C H A P. VI. SECT. I.



Of CARCASSES.

THE Carcass is a sort of cartouch for the mortar; its figure is that of a spheroid, lengthened at one end, and flatted at the other; it is composed of 2 arches of a circle, or rather an oval, of iron, which intersect each other at right angles, and terminate in a kind of little iron pan, or dish, which forms the flat end of the carcass, and is called its (*culot*) or breech.

The interior part of this carcass is filled with grenadoes, and pistol barrels, charged with leaden balls, as also with pitch, and whole powder, and the whole afterwards covered with okum dipp'd in pitch, and facking, which last serves as a wrapper; a hole is made in this cloth, to put such a fuse through into the carcass, as is used in bombs, and the carcass is in the same manner discharged from a mortar.

It is said Carcasses were invented towards the year 1672, and used by the *French* in the wars between *France* and *Holland*.

From the *Figures* 2, 3, and 4, in *Plate IX.* all that relates to carcasses may be easily learnt. Pl. IX.
Fig. 2,
3, 4.

Fig. 2. shows the iron frame of the carcass, its breech and ribs, or the arches of iron it is composed of.

Fig. 3. shows the manner of charging it.

Fig. 4. represents it as it appears when ready to be fired in the mortar.

The carcass weighs about 20 pounds, is 12 inches high, and 10 inches diameter in the middle. The use of this carcass is to set

fire to the places on which it is thrown. The various parts of its composition cannot fail of causing great disorder where it falls; the pitch which is poured into it, so as to fill all the vacancies between the rest of its contents, renders the fire tenacious, and the small barrels it is charged with, and which do not go off all at one time, deter every one from coming near enough to extinguish it, and it is for that reason they are put in. But the use of this kind of fire-ball is notwithstanding abolished, if we may be allowed the expression, because it has been observed that its effect is very little superior to that of a bomb, and that it is notwithstanding attended with a much greater expence.

SECT. II. Of Partridge Mortars, for firing Bombs and Grenadoes together.

BEsides the mortars already mentioned, one has been invented of a particular construction, designed to discharge a bomb and a number of grenadoes at the same time. *Fig. 5. Pl. IX.* represents this mortar mounted upon its carriage: it is a common mortar; surrounded by 13 other little mortars, bored round its circumference in the body of its metal, as appears in *fig. 6.* of the same plate; that in the middle is charged with a bomb, and the others with grenadoes. The touch-hole of the great one being fired, and communicating with those of the little ones, discharges at once both the bomb and the grenadoes.

This kind of mortar is called a *partridge mortar*, because, when it is fired, the bomb mounts with the grenadoes, almost like a covey of young partridges, of which the bomb represents the mother. They have been very little used in *France*; in the various experi-

experiments made with them, related by M. *St Remy*, some of the grenadoes have always failed to burst, and sometimes even the bomb itself has not taken effect. The allies, however, made good use of them during the war in 1701, and more especially at the siege of *Lisse* in 1708, and the defence of *Bouchain* in 1712.

C H A P. VII.

Of the OBUS.

THE Obus is a sort of mortar, which is to be fired horizontally like a cannon, and has a carriage with wheels, or a wheel-carriage the same as cannon.

This piece is represented by *Fig. 1. Plate X.* It is used to throw bombs into the platform of a bastion, or the middle of a party of men*. The *English* and *Dutch* were the inventors of this kind of mortar; the first which were seen in *France* were taken at the battle of *Nerwind*, which the marshal *de Luxemburg* gain'd against the allies in 1693. Pl. X.
Fig. 1.

* Our pieces of this kind, called *Ha-witzers*, are 8 inches in the bore, above 3 feet long, and about ten hundred weight.

C H A P. VIII.

Of the Arquebuse a Croc.

THE Arquebuse a Croc is a fire-arm, still found in most old castles, pretty much resembling the barrel of a musket, and sustained by an iron swivel, which is fastened to its barrel,

barrel, and supported by a sort of foot called a *chevalet*, or three-legged horse. This piece was formerly much used, to mount on battlements, and at loop-holes, but is now almost entirely neglected, being used no where but in old forts and castles where it is found. The barrel of the arquebuse a croc is larger than that of a musket, but much less than a cannon's; they are charged in the same manner as a cannon, and, like them, fired with a match; the range of this piece is greater than that of a musket.

We shall take no notice in this work, either of the fusil or musket, the pistol or the musketoon, because these are fire-arms already sufficiently known; and we have already treated of all those which an officer ought to be acquainted with, except the carabine and petard.

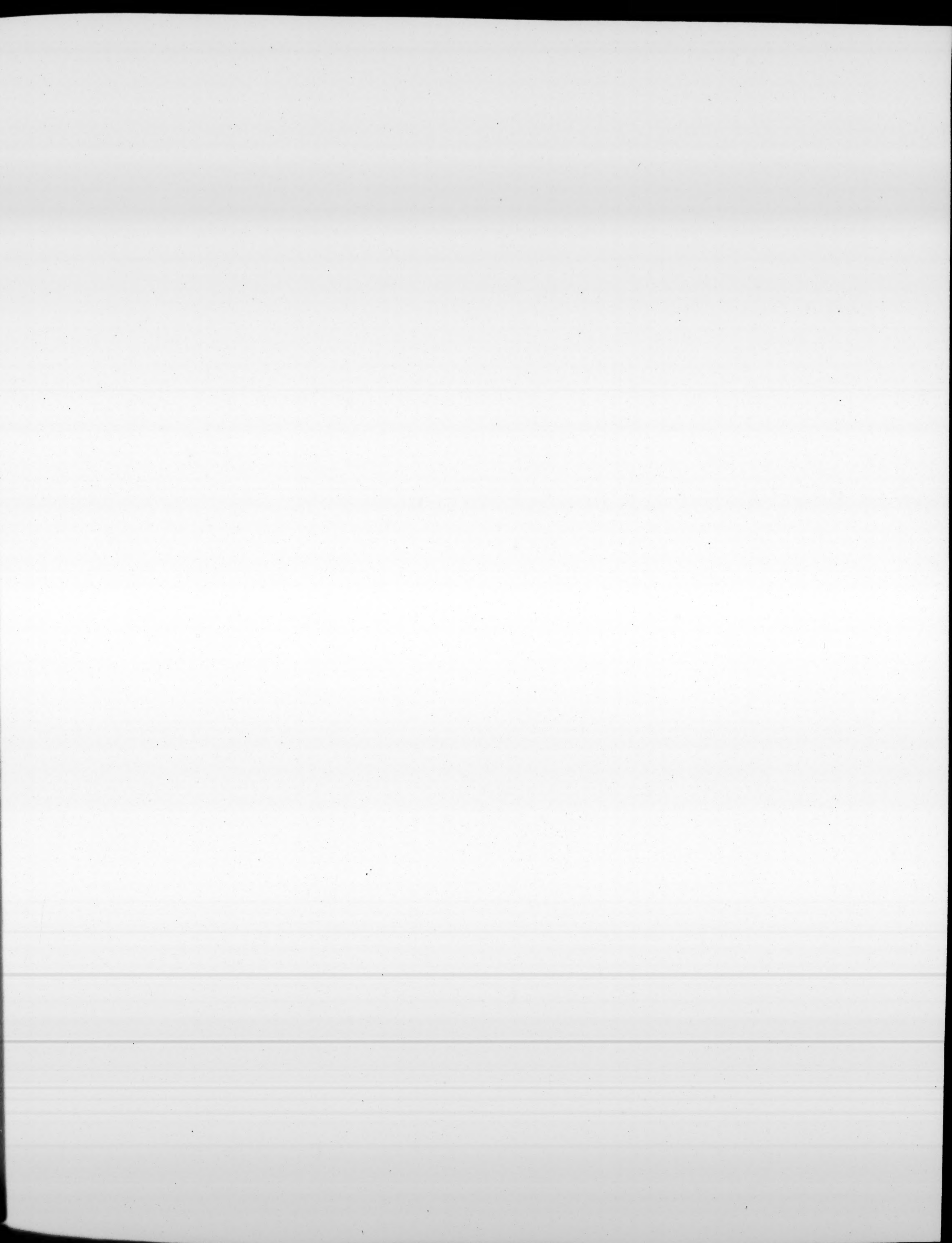
CHAP. IX.

Of the CARABINE.

THE Carabine is a sort of musketoon, the barrel of which is rifled spirally from the breech to the mouth, so that when the ball which is forced into it is again driven out by the strength of the powder, it is lengthen'd about the breadth of a finger, and mark'd with riddle of the bore.

The barrel of the carabine is three foot long, and the piece is four foot long, including the stock; it has an iron rammer, and the bullet is first driven into the mouth of the piece with a short iron pin, called a *driver*, striking it on the end with a small hammer made for that purpose,

The





X.

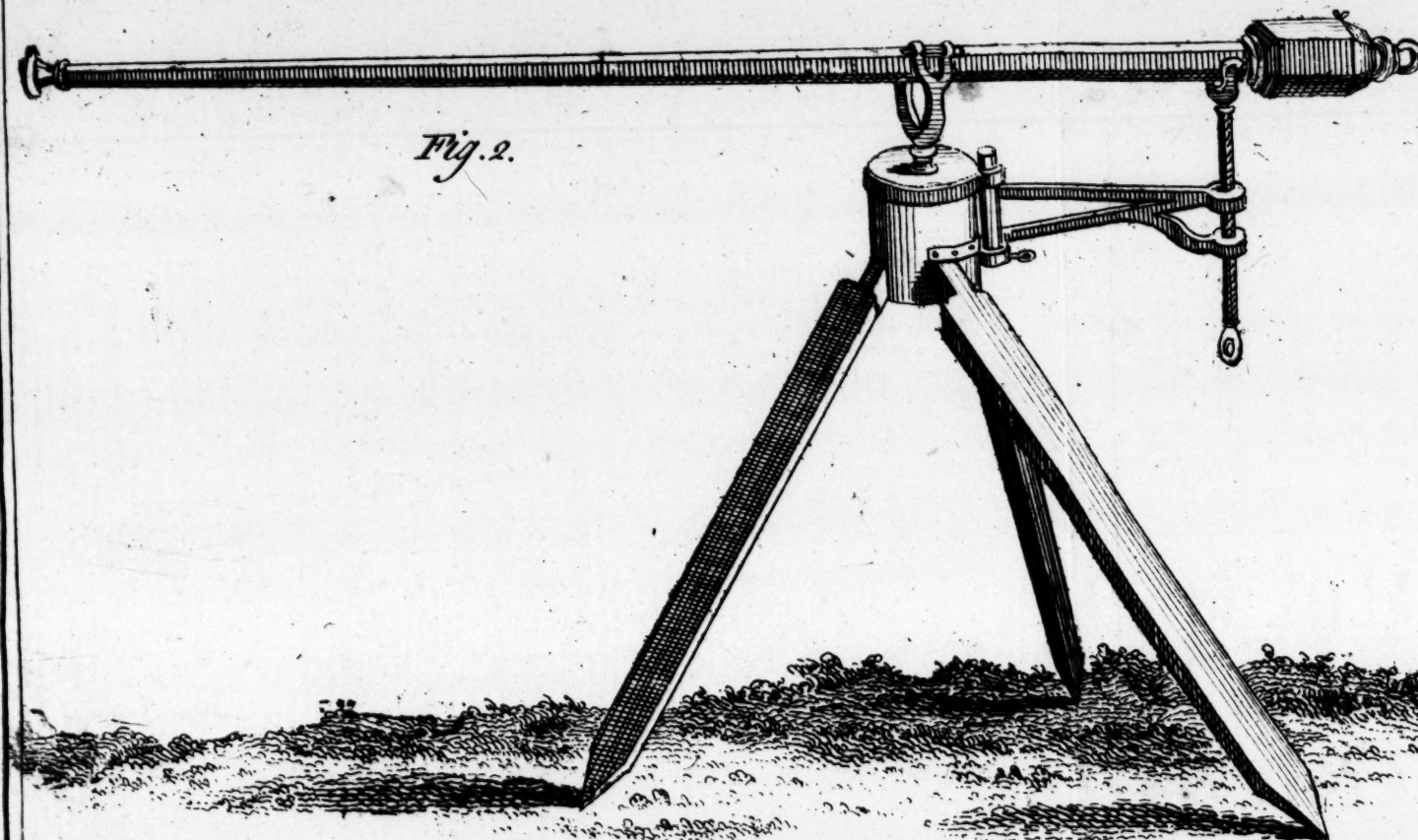


Fig. 2.

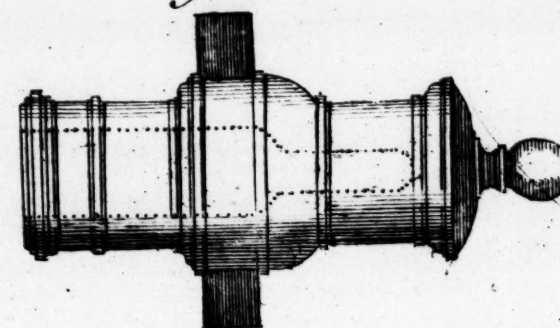


Fig. 1.

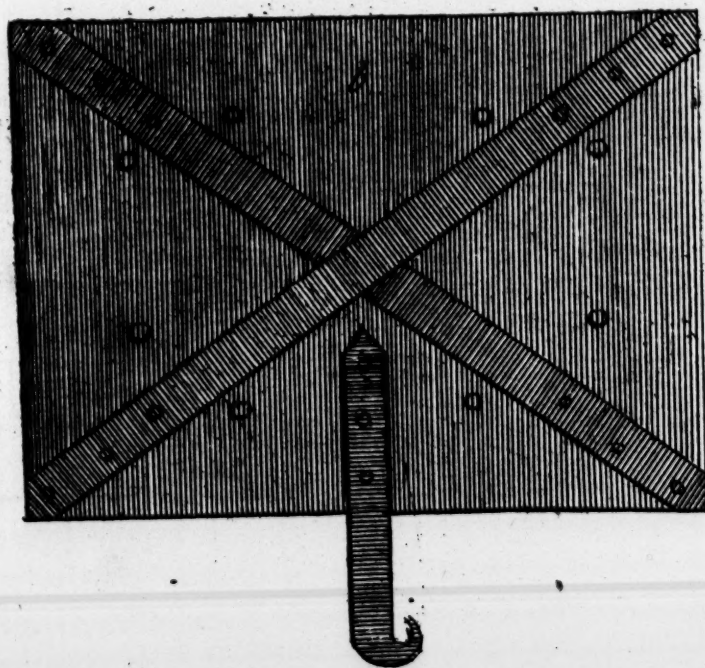


Fig. 4.

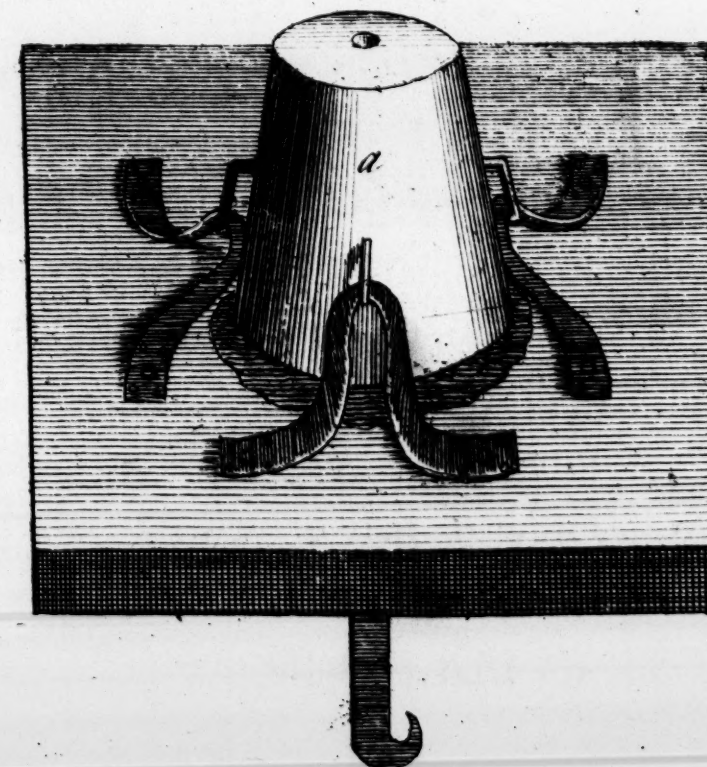


Fig. 3.

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The carabine has a much greater range than the fusil, or musket, because the riddle of the barrel impedes the ball, which by that means makes the greater resistance at the first inflammation of the powder, and giving time for the whole charge to take fire before it goes out of the bore, it is at length thrown out with a greater force than from the common musket.



Of the PETARD.

THE Petard, *a*, is a machine made of brass, as the cannon; its figure is exactly that of the frustum of a cone, or, as the chevalier *de Saint Julien* terms it, of a *Spanish* hat; it is concave within, its height it commonly 10 inches, and its diameter at the top 7 inches, and at its bottom or aperture 10 inches; it has, like a cannon, a touch-hole in that part opposite to its mouth, which may be considered as its breech; as to its size, it may be either bigger or less, and in general it ought in this respect to be proportioned to the effect it is intended to produce.

PL. X.
Fig. 3, 4.

The ordinary method of charging the petard is, to force into it as much fine powder as it will hold without being pressed down, this powder is then covered with paper doubled, or a piece of old hat, the whole width of the bore, upon which is also placed a kind of wooden plug, or bung, of the same diameter with the bore of the petard, which is forced down upon the powder by striking it smartly with a mallet, taking care however that it be not driven in so forcibly as to bruise the powder; the rest of the petard is then filled

filled up with tow dip'd in bees-wax or pitch, and the whole is covered with a wax'd cloth.

PL. X.
Fig. 3, 4.

The petard has four handles, by which it is strongly fastened with bands of iron to a madrier, that is, a plank 2 or 3 inches thick, represented by *Fig. a.* The madrier has on the side opposite to that on which the petard is placed, two iron bandages, which cross it diagonally, or from angle to angle; it has also an iron hook, to fasten the madrier to the place where it is to be fixed. For these bands and hook see *figure d.*

The petard is used to break open the gates of towns and castles, intended to be taken by surprize.

For this purpose an approach is made to the gate, in such a manner as to prevent a discovery, and with a screw, or some other instrument, the madrier is fastened by its hook to the door intended to be broken open, which being done, the fuse of the petard is fired, and this being filled with a composition that burns out slowly, gives time to the petardier, or person who fixes the petard, to retire; the fuse having fired the powder the petard is charged with, this powder presses the madrier against the door with such violence, that it bursts it open, or makes a breach in it.

The business of a petardier is extremely dangerous, few officers, according to M. *St Remy*, returning from this expedition. For if the petard is perceived by the garrison, they will be sure to fire at the operator, either from the pieces planted over the gate, or those to the right and left, and scarce ever miss him.

The use of the petard is not ancient, this machine being entirely a modern invention, according to the chevalier *de Ville*, first discovered and used in *France*, from whence it has passed into other countries.

Henry the 4th, being then only king of *Navarre*, surprized *Cabors*,
the

the capital of *Quercy*, with a petard in 1579, having made an essay of it some time before, at a little castle of *Rovergue*. *Of the Petard.*

The petard has been much more used than at present, tho' places are not less frequently taken by surprize; it may, however, be used with advantage on several occasions, and those who would know all the precautions necessary to render it successful, may consult the chevalier *Ville*, who has treated the subject as minutely as they can wish.

Before we leave this article we shall observe, that the petard is made use of to throw great stones into a town. *M. Blondel* gives an instance of it at the end of his treatise on the art of throwing bombs, which perhaps will not be displeasing here, as it may serve to give some idea of a method of throwing bombs, in cases of necessity, even without the help of a mortar.

“ The *Poles*, says *M. Blondel*, assisted with auxiliary troops of
 “ the emperor's under the conduct of the count *de Souches*, in 1659
 “ besieged the town of *Thorn*, in *Prussia*, then held by the *Swedes*,
 “ and often threw in stones of a monstrous size, and great frag-
 “ ments of milstones and freestones of 800 weight, without the
 “ use of mortars, in the following manner.

“ In the beaten ground near the counterscarp they sunk beds,
 “ exactly of the size and figure of the stone they intended
 “ to throw, made flat and level at the bottom, which was
 “ inclined towards the town, in such an angle as they judged
 “ it ought to have for the direction of their shot. In the middle
 “ of this bottom they sunk another hole, still deeper, in form of
 “ a chamber, in such a manner as that the axis of this last hole
 “ passing through the stone's centre of gravity, was perpendicular
 “ to its bed, and the same as its line of direction; they filled this
 “ hole with powder, if the earth was firm enough for the purpose;

K

and

“ and if not, they put in a petard of a size proportioned to the
 “ weight of the stone, which resting upon the flat side of the
 “ madrier of the petard, or the stopple of its chamber, was im-
 “ pelled by the whole force of the powder, which they lighted
 “ by means of a thread steep'd in brandy, and the composition of
 “ a fuse, and the stone rising to a great height, fell into the town on
 “ the place intended, and broke to pieces all it met with in its fall.

CH A P. XI. SECT. I.

Of Batteries, and their Construction:

ALL places where cannon, mortars, &c. are mounted, are called batteries, whether to fire on an enemy, or to attack or destroy a fortification.

In an engagement cannon are fired without being covered, that is, without there being any ground thrown up to cover or defend the persons appointed to charge and work them. For as the pieces in these cases have no fixt situation, but are perpetually changing place as the general from time to time sees proper, the difficulty of covering them is evident, and the haste, in which these kind of actions are performed, does not permit the use of that precaution which would render the service much less dangerous. But in the attack of a place it is otherwise, the cannon are then fixt firmly each in its proper place, and it is absolutely necessary to their being made use of, that they should be placed behind a parapet, thick enough to resist the cannon shot of the besieged.

The construction of a parapet is what is properly called the
 con-

construction of a battery; we shall give the particulars of it, as they stand in M. *de Vauban's* memoirs. Of Batteries.

The bed of the cannon, that is, the spot of ground on which it is placed, should, if possible, be raised some feet above the level of the field.

The parapet should be three fathoms thick, and seven foot and an half high.

These parapets are constructed of earth, and fascines, which are a kind of faggots.

The situation and extent of these batteries are first marked out (so as they may be parallel to the parts of the fortification intended to be destroyed), by laying down a line, or the match-cord; this done, the ground before the battery is broke, and a small trench opened; a bed of the earth that is dug out is first laid, and well beaten down; then a layer of fascines is placed transversely upon the earth, or so that their length shall reach from side to side of the parapet, crossing it at right angles, and so alternately a bed of earth and a layer of fascines, the fascines well fastened together, and stakes driven through them, so as to make the several layers of fascines and earth, as it were, one body; both sides of the parapet are also faced or lined with fascines, laid lengthways, or parallel to the parapet, and well fasten'd with stakes to the inside of it.

This parapet being raised two feet and an half, or three feet, the embrasures must be marked out on the outside. Embrasures are well known to be openings in parapets to receive the cannon, and the part between two embrasures is called the merlon; from the middle of one embrasure to another there ought to be 18 feet, the embrasure ought to be three feet wide on the battery side, and 9 feet on the outside of the parapet.

The embrasures being marked out, the rest of the parapet, called

the epaulment of the battery, must be raised, leaving the space marked for the embrasures open; that part of the parapet above the embrasures must have a proper slope, or shelving, that the materials of the parapet or of the merlons may not be beat down into the embrasures.

That part of the parapet, which reaches from the ground to the bottom of the embrasures, is called the knee of the battery.

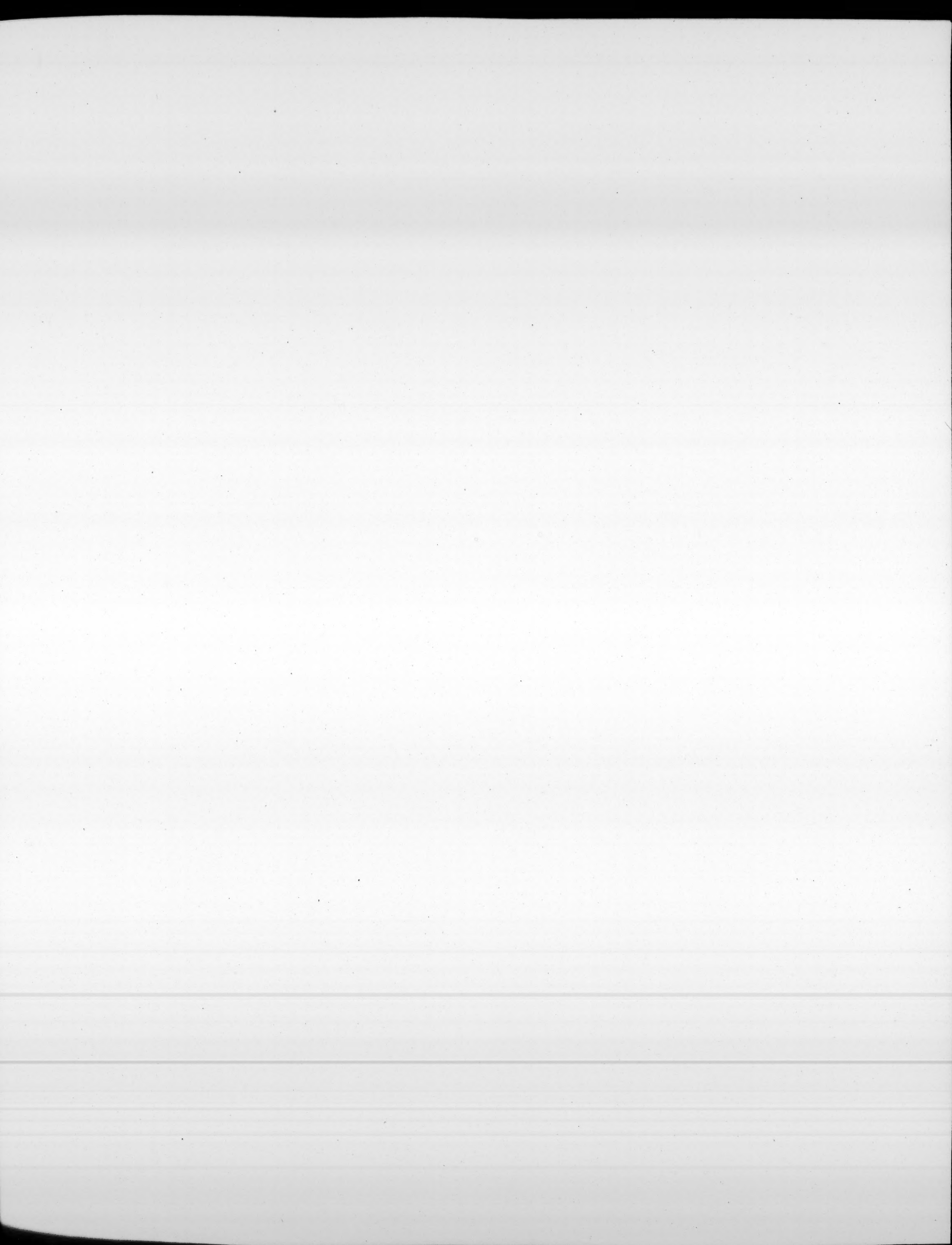
The parapet being finished, platforms must be prepared over-against the embrasures, to place the cannon upon.

These platforms are a kind of strong floors, made to prevent the cannon from sinking into the ground, and to render the working of them more easy. They are composed of joists, or pieces of wood laid lengthways, the whole length of the intended platform; and to keep them firm in the places they are laid in, stakes must be driven into the ground close to them on each side; these joists must then be covered with very thick planks, laid parallel to the parapet; and over that part of the last, which touches the inside of the parapet, a kind of thick girder, or rafter, must be placed, called a *heurtoir*, or *knocker*, because when the cannon is fired, the wheels of its carriage first knock or strike against it, and immediately afterwards recede from it, by the effort of the powder made against the breech of the piece, which is the cause of what is called its recoil, as we have said before.

As a check to this recoil, and to render it as little as possible, the ground, on which that part of the platform is laid, which is farthest from the parapet, should be raised, as much as circumstances will permit, higher than the part nearest the parapet.

Platforms ought to be about 18 or 20 feet long, 7 and an half wide near the parapet at their narrowest part, and 13 at the widest.

When the platforms are finished, the cannon must be brought to



13. 1/2 a high

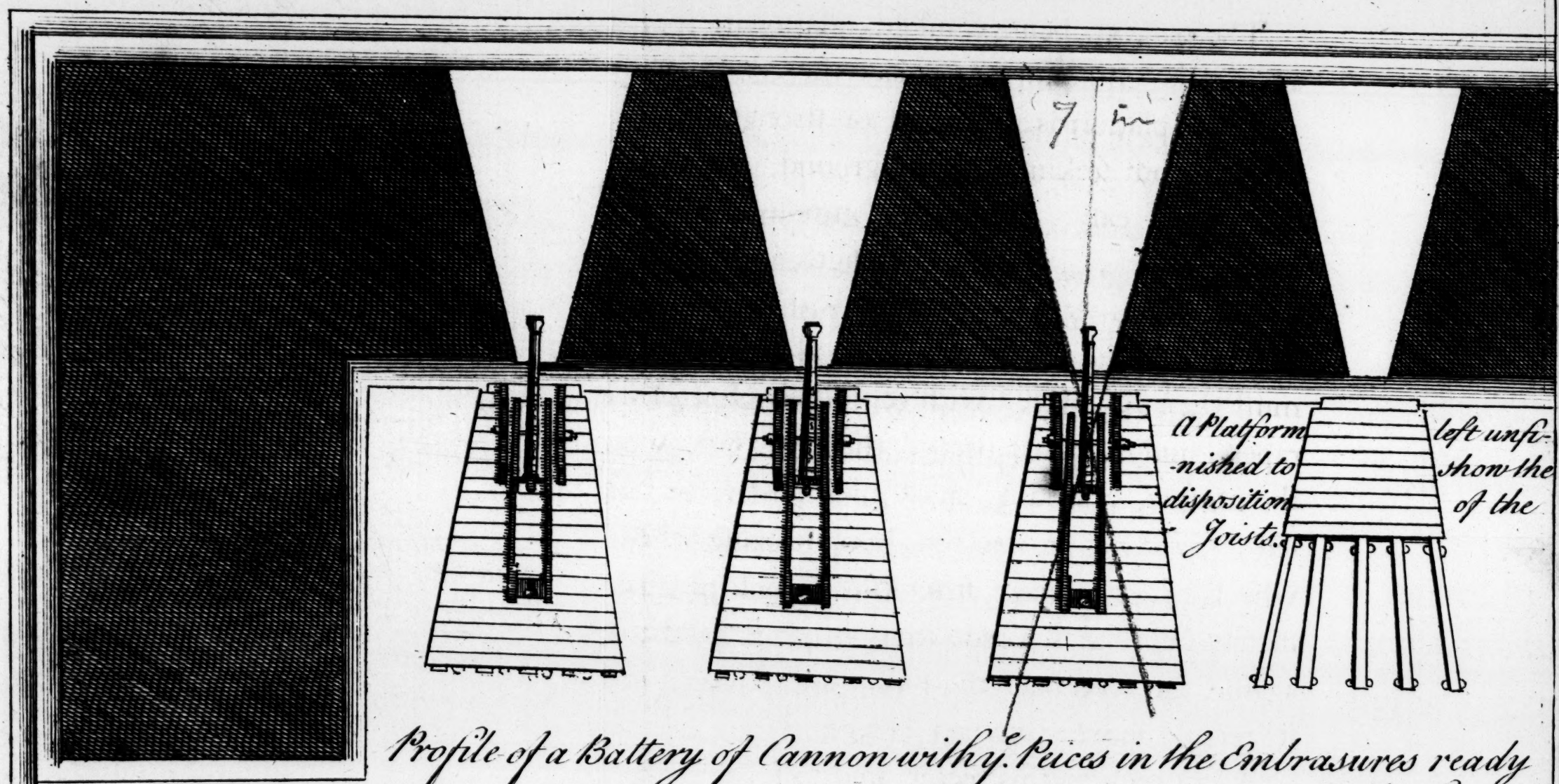


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Plan of a Battery of Cannon.

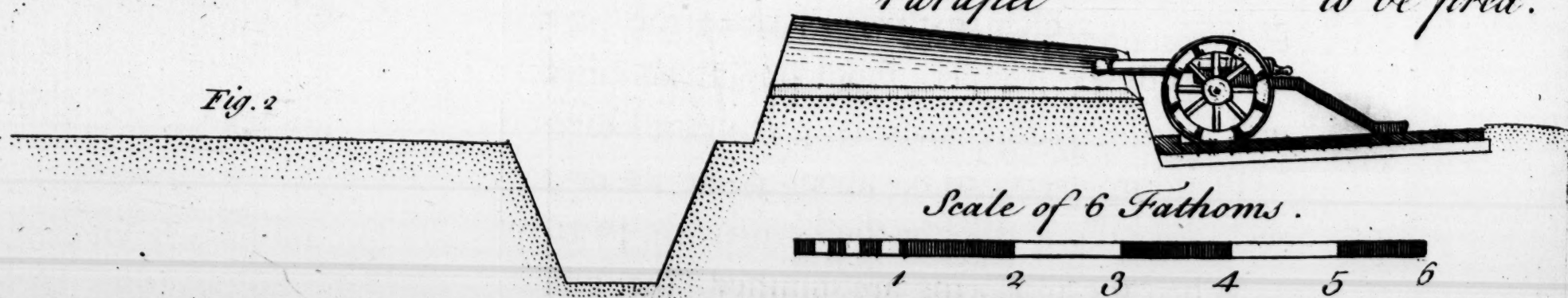
Fig. 1.

Fosse or Ditch.



Profile of a Battery of Cannon with y. Pieces in the Embrasures ready to be fired.

Fig. 2



J. Jefferys sculp.

to the batteries, and placed with their carriages on the several platforms allotted them.

It is usual to make little cells or cavities near to the batteries, at a convenient distance, in which to keep the gunpowder. These cells are covered with clay, or something of the like kind, to preserve them from being fired, and are called little magazines of the battery. A place is prepared at a greater distance, and not so near the battery, where a larger quantity of powder is kept, which serves as a magazine to the smaller places just mentioned. The powder is divided thus, to prevent accidents by fire, and these magazines are guarded by soldiers sword in hand.

All that remains concerning batteries of cannon, after what we have said on the subject, will be seen by the figures in *Pl. XI.*

PL. XI.
Fig. 1, 2.

Fig. 1. represents the plan of a battery, with its platforms, and the cannon placed thereon, facing the embrasures.

Fig. 2. shows the profile of a battery, with a piece of cannon in its embrasure, ready to be fired.

SECT. II. *Of Batteries of Mortars.*

AFTER having treated of the batteries of cannon, it is proper to give some account of the batteries of mortars; but these differ little from the former. They are constructed in the same manner, except that they have no embrasures; they have also platforms made in the same manner with those of cannon. *Pl. XII.* PL. XII. exhibits the plan of one of these batteries, with a profile representing a mortar at the moment of giving fire.

When the enemy is near enough to see or command the batteries in flank, his view must be cut off by continuing the parapet of the battery in another angle, as represented *Fig. 1. Pl. XI.*

PL. XI.
Fig. 1.

The

The bullets and bombs are laid in readiness down by the merlons, between the embrasures.

SECT. III. *Of different kinds of Batteries.*

THERE are batteries of various kinds; as sunk, direct, sweeping, reverse, cross, and rebounding batteries.

Sunk batteries have their platforms sunk below the level of the field, so as that the ground serves for the parapet in which embrasures may be made.

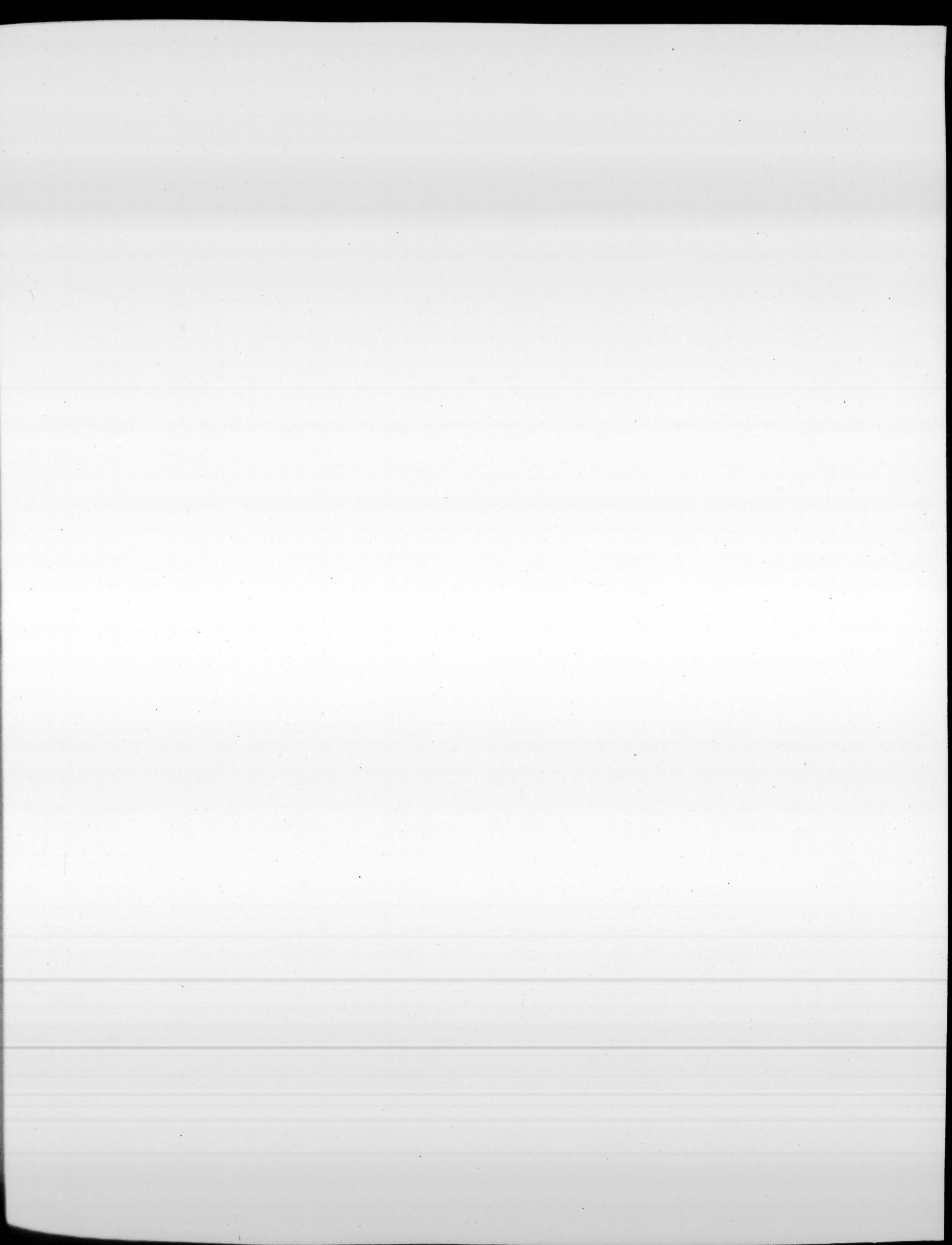
Direct batteries are those which batter the sides of the work before which they are placed almost at right angles.

Sweeping batteries, (or batteries *d'enfilade*) are those which scour or sweep the sides of some work in a strait line.

The reverse (*revers*) are those which batter from behind, that is, play on the backs of those posted on the work to defend it.

Cross batteries are those the fires of which would cross each other almost at right angles, if continued after their meeting.

Rebounding batteries, (or batteries *d'echarpe*) are those whose strokes make no more than an angle of 20 degrees with the faces or sides of what they are directed against. These are also sometimes called *glancing batteries* (*de bricole*), because the bullet only glancing as it were upon the place it is directed against, is thrown off to the parts adjacent, almost like the bricole, or transverse stroke at billiards, which falls on the cushion in an oblique direction.

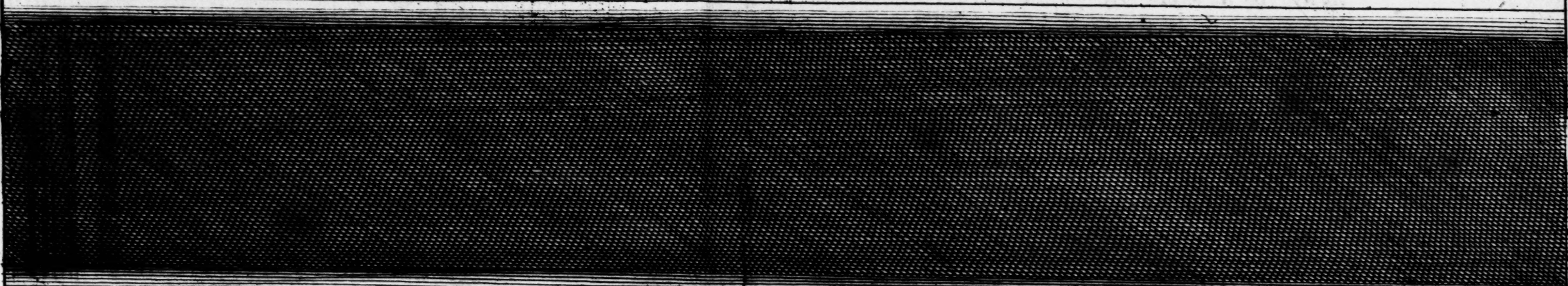




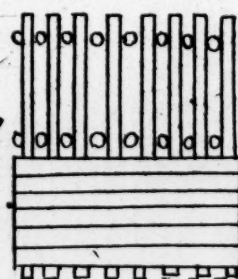
Plan of a Bomb Battery

Fig. 1.

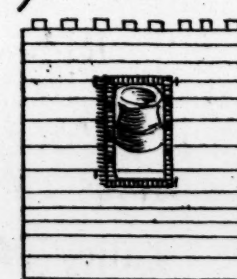
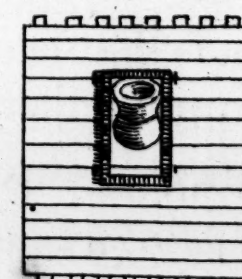
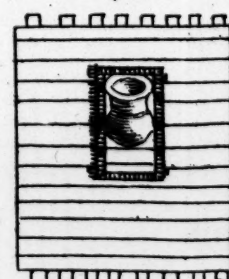
Troop or Ditch



A Platform unfinished w^{ch} shews the disposition of the Joists.

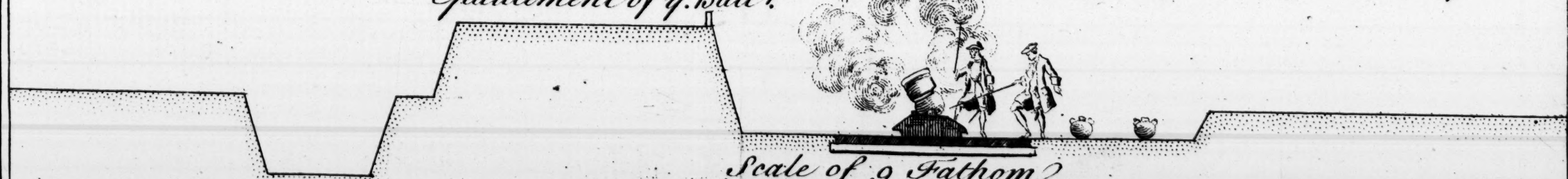


Platforms finished with the Mortars upon them.



Parapet or Epaulement of y^e Batt^y.

Profile of a Bomb Battery



Scale of 9 Fathom

T. Jefferys sculp.

CHAP. XII. SECT. I.

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C H A P. SECT. I.*Of MINES.*

MINES, at present, make so essential a part of the attack and defence of fortified places, that the giving some idea of them cannot be dispensed with in this work, which is proposed to exhibit all the machines and methods used both to prepare and preserve them.

SECT. II. *A Description of Mines, and their Use.*

BY a mine is understood a kind of subterraneous gallery, which is carried on till it comes under the places intended to be blown up, and at the end of which a cavity is made, sufficient to contain the quantity of powder requisite to blow up whatever is erected or happens to be over it.

The end of the gallery, or the cavity that receives the charge of the mine, is called its chamber, or the furnace of the mine.

The design of mines then is, to blow up whatsoever lies over their chambers; and, in order to this, it is necessary that the powder they contain should meet with less resistance in this part than towards the gallery, otherwise it would not blow up.

That the powder may not fail to explode by the upper part of the chamber of the mine, one part of the gallery must be walled up with masonry, fascines, stones, and pieces of timber, by layers interchangeably, one joining to the other, &c. The mine is fixed
by

by means of a long leathern pipe, or bag, called a faufage, which reaches from the chamber of the mine to the opening or end of the gallery, and something further. And to prevent the powder from growing damp, it is placed in a small wooden gutter called an [*auget*] *ogee*; the diameter of the faufage is about an inch and an half.

The faufage having taken fire, communicates it to the chamber of the mine; and the powder there being inflamed, makes an effort on all sides for room to dilate itself, and finding every where a greater resistance than from the top of the chamber, its principal effort is directed to that place, which is by this method blown up with all that is over it.

SECT. III. *Observations and Principles for the calculation of Mines.*

THAT the mine may produce the effect proposed, it is necessary that it should be charged with a sufficient quantity of powder; for too small a charge will only give the ground a little shock, without blowing it up; the charge may even be so small, as to produce so languid and insensible a motion, that it will not be at all communicated to the exterior part of the mine, or outward surface of the ground. On the other hand, too great a charge will be an expence of powder to no purpose, or perhaps produce a greater shock, and more confusion than is desired.

To avoid all these inconveniences, it is necessary to know,

1st, The quantity of powder requisite to blow up a cubic foot of earth. There are earths of different sorts, some heavier and some lighter, some very tough and tenacious, others the parts of which are easily separated; it is therefore proper to know how much powder will blow up a cubic foot of each of these sorts of earth.

2^d, The

2d, The solid figure of the ground must be known which the powder is to blow up, and its solidity measured to ascertain the quantity of powder requisite to charge the mine.

The solid quantity of earth blown up by the mine is called its excavation, and the hollow left in the ground from whence it is thrown, is called the tunnel of the mine, from its resemblance to the implement of that name.

The knowledge of these particulars must be gained from experience; this alone can teach us what quantity of powder is necessary to raise a certain weight of the same figure as the tunnel of a mine, or, which is the same thing, the solid intended to be blown up.

The different soils, according to the authors who have treated of mines, may be reduced to the four principal kinds following.

1. Hard gravel, which is also called tuff.
 2. White clay, or potters earth, used for the making of bricks and tiles.
 3. Dry sand, or loose earth.
 4. The old and new masonry.
- A cube foot of tuff, or the hard gravel, weighs 124 pounds;
 of potters earth 135 pounds.
 of dry sand 95 pounds.

With respect to a cube foot of masonry, its weight cannot be ascertained exactly, because it very much depends on the nature of the different stones, or materials it consists of.

It is supposed, that to raise a cubic fathom of gravel, or tuff, in firm ground, eleven pounds of powder are requisite, or thereabouts.

That to raise a cubic fathom of potters earth, or clay, in firm ground, 15 pounds are requisite.

That a cubic fathom of dry sand requires at least 9 pounds.

And, lastly, for a cubic fathom of masonry 20 or 25 pounds of

L

powder

Of Mines powder are required, if the masonry be above ground, and 35 or 40 pounds, if it be foundation.

Supposing these experiments to have been made with all possible care and exactness, it will not be difficult to find the quantity of powder requisite to charge a mine, if the contents of the solid earth to be blown up be known.

This solid was at first taken for a cone reversed, afb , of which the point or summit f , terminated the middle of the chamber of the mine; afterwards for the frustum of a cone, as $caf bdc$; but M. de Valliere*, that celebrated general, so well known for his great skill in artillery, and principally in the science of mining, having examined this solid with more attention, found that its figure differed somewhat from the frustum of a cone, and approached nearer to the shape of the curved solid, called by geometricians a *paraboloid*; and that the chamber, or *furneau*, of the mine, after the explosion, was a little higher than the bottom of the excavation, because the powder taking fire, presses against the bottom of the earth (that forms the roof or superior part) of the chamber, and consequently must force it closer together, and in some measure drive it in.

The section, or profile, of the paraboloid formed by the excavation of a mine, is represented by the curve line adb , called a *parabola*, and is of the same kind with that described by the flight of a bomb; and, in general, of all other bodies projected parallel or oblique to the horizon; the chamber, c , appears in a point of the space included within this curve, which is called its *focus*.

The paraboloid may be considered as a sort of frustum of a cone, the upper part of which is rounded in form of a jocky's cap, and the sides a little incurvated.

In many experiments, made long ago at *Tournay*, to examine the

* What Valliere says on this subject is in a dissertation annexed to the 3d volume of the *French Polybius*.

the figure of the solid formed by the excavation of mines, it was observed, that the perpendicular ce elevated from the chamber to the superficies of the earth, was equal to the radius of the circle formed by the exterior part of the excavation, that is, to the circular mouth of the tunnel. This perpendicular line, erected from the top of the chamber, which shows the height or thickness of the ground to be raised, is called the line of least resistance, because it ought to represent the place where the powder, finding the least resistance, forces itself out of the chamber; it was also discovered by these experiments, that the radius of the little circle, formed by the end of the excavation next the chamber, was half the radius of the great circle, or the mouth of the mine.

Geometry furnishes rules for finding the solidity of the frustum of cones, as well as paraboloids. Thus, supposing the line of least resistance known, and the excavation of the mine to be either the frustum of a cone, or a paraboloid, the cubic fathoms contained in either of these bodies may be found, and consequently the quantity of powder the mine ought to be charged with, in order to blow them up, ascertained.

To render this still plainer, we will illustrate it by an example. Let us suppose (to make the calculation more simple) that the excavation of a mine is the frustum of a cone; the small difference there is between the measure of this and the paraboloid permits the choice of either, without any material error; and as the measure of the frustum of the cone is the most simple, we shall give that the preference.

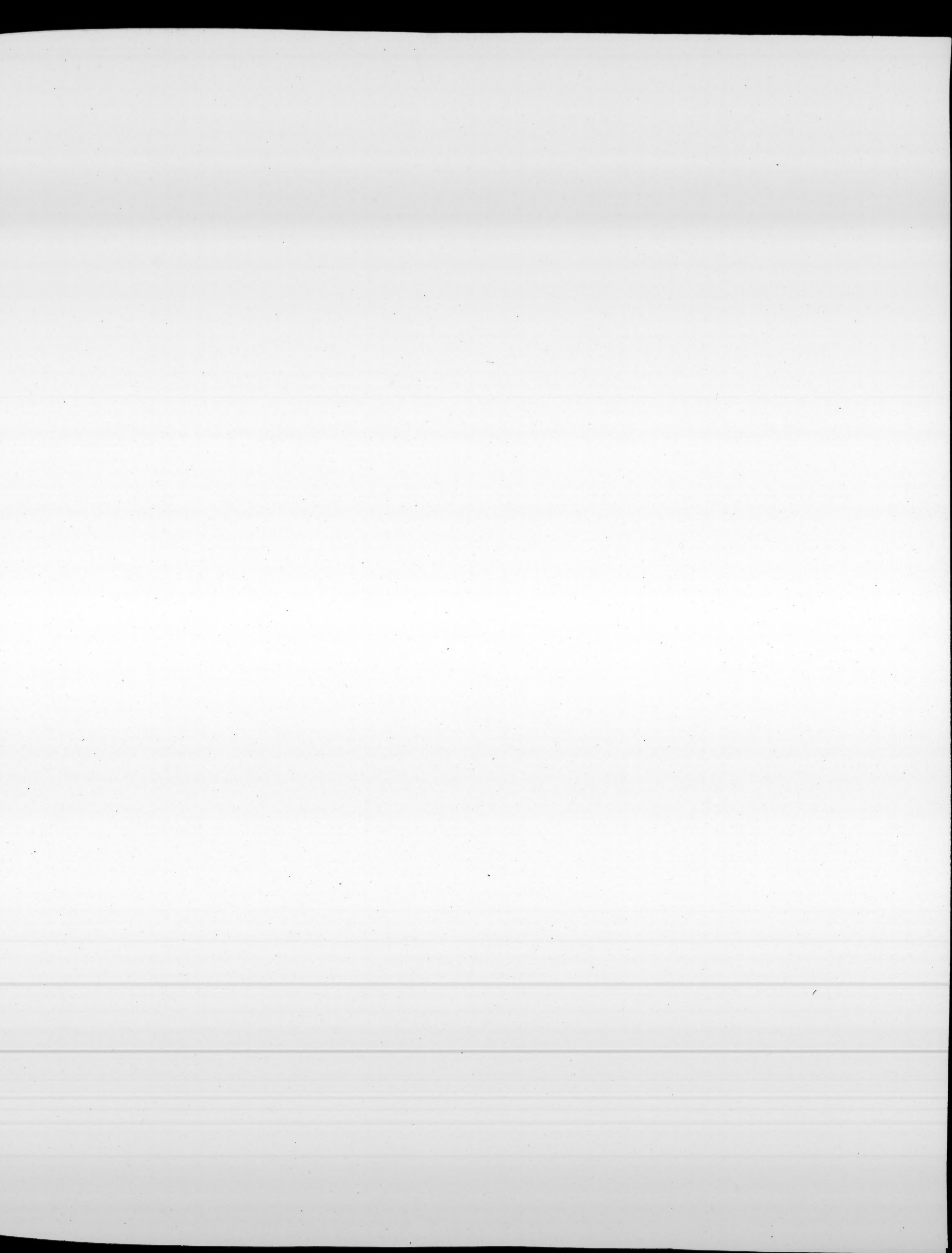
Let f be the cell, or chamber, of a mine; fc the line of least resistance, in length 10 feet; cb the radius of the greater circle of the excavation, equal to the line of least resistance, and consequently also 10 feet; fg the radius of the smaller circle

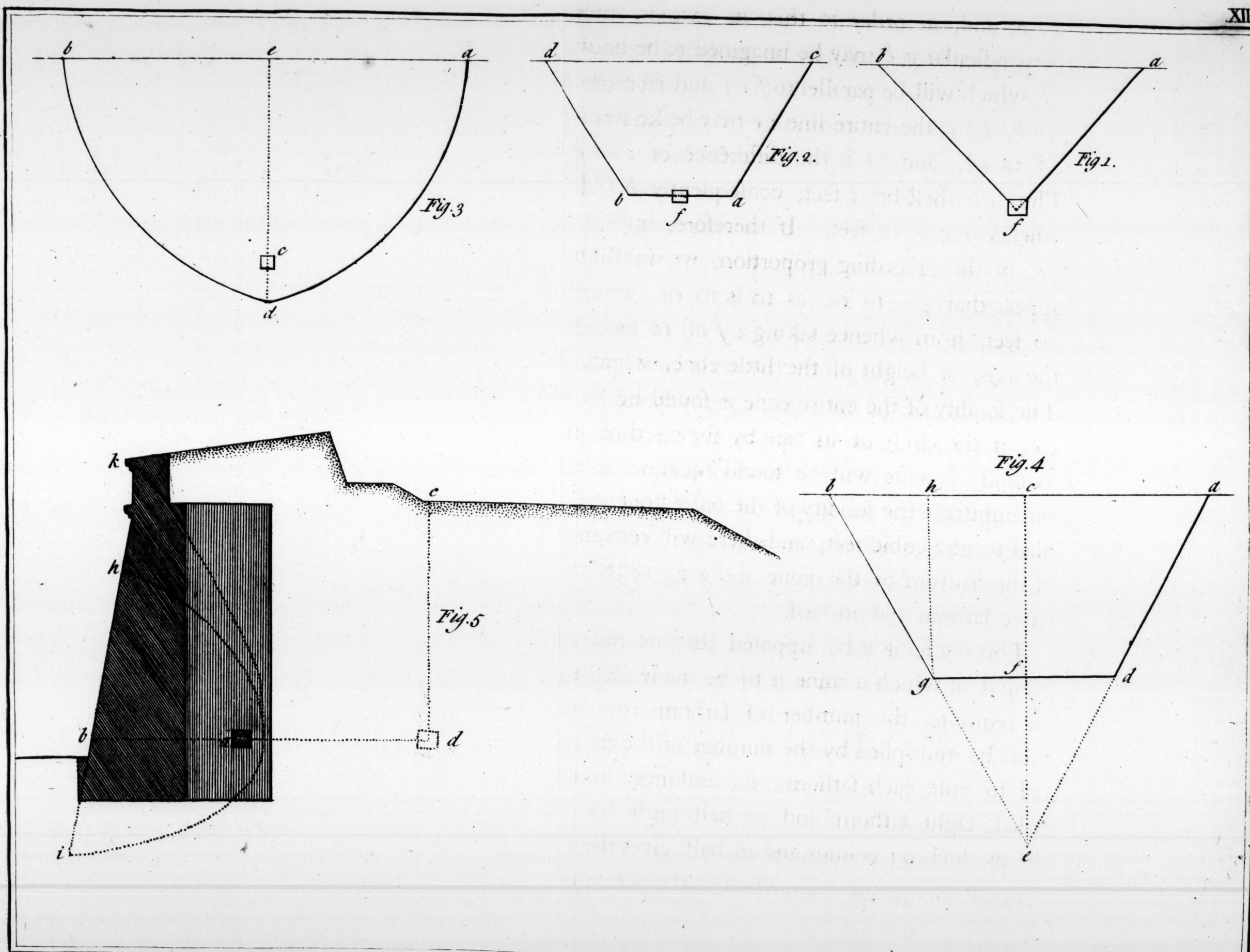
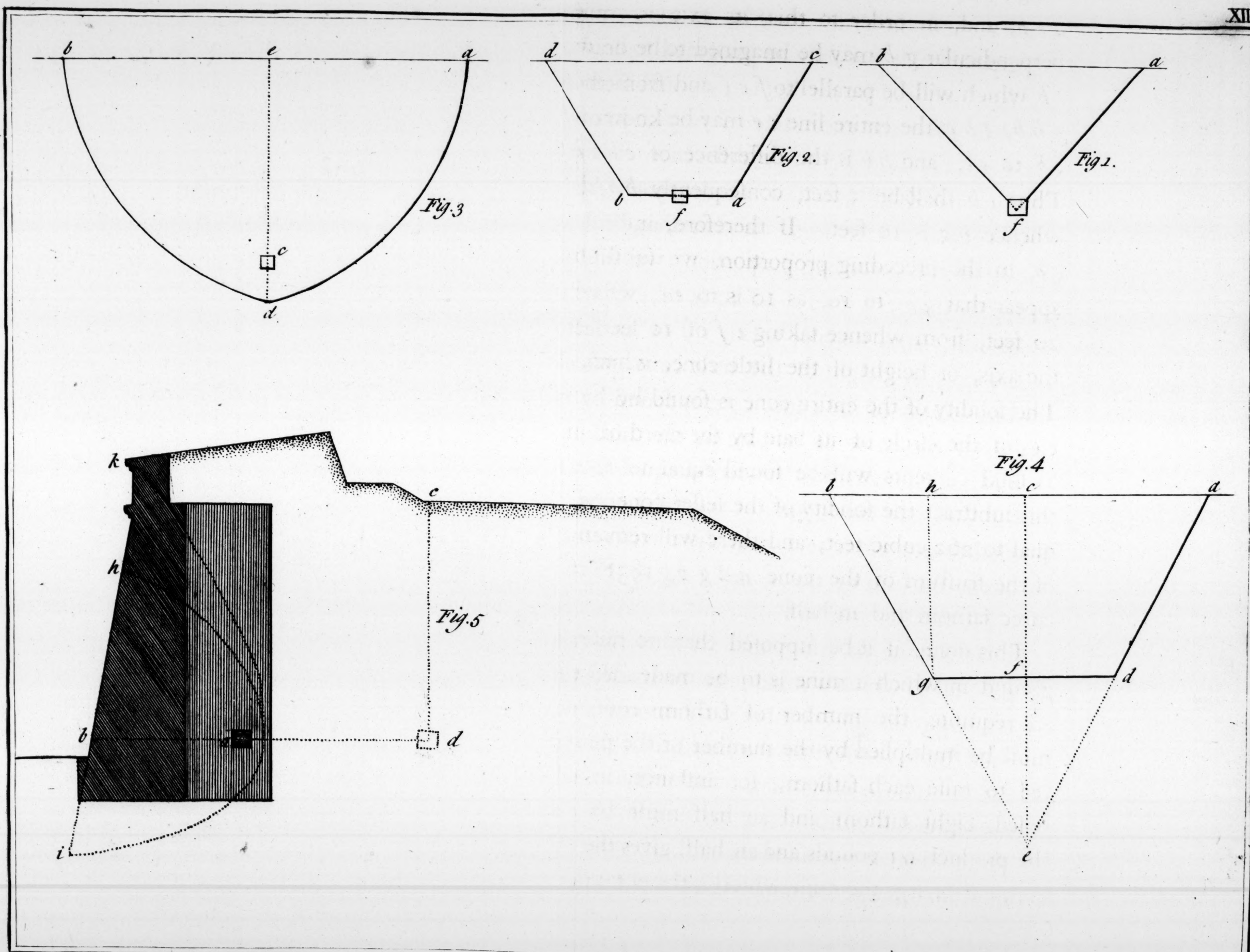
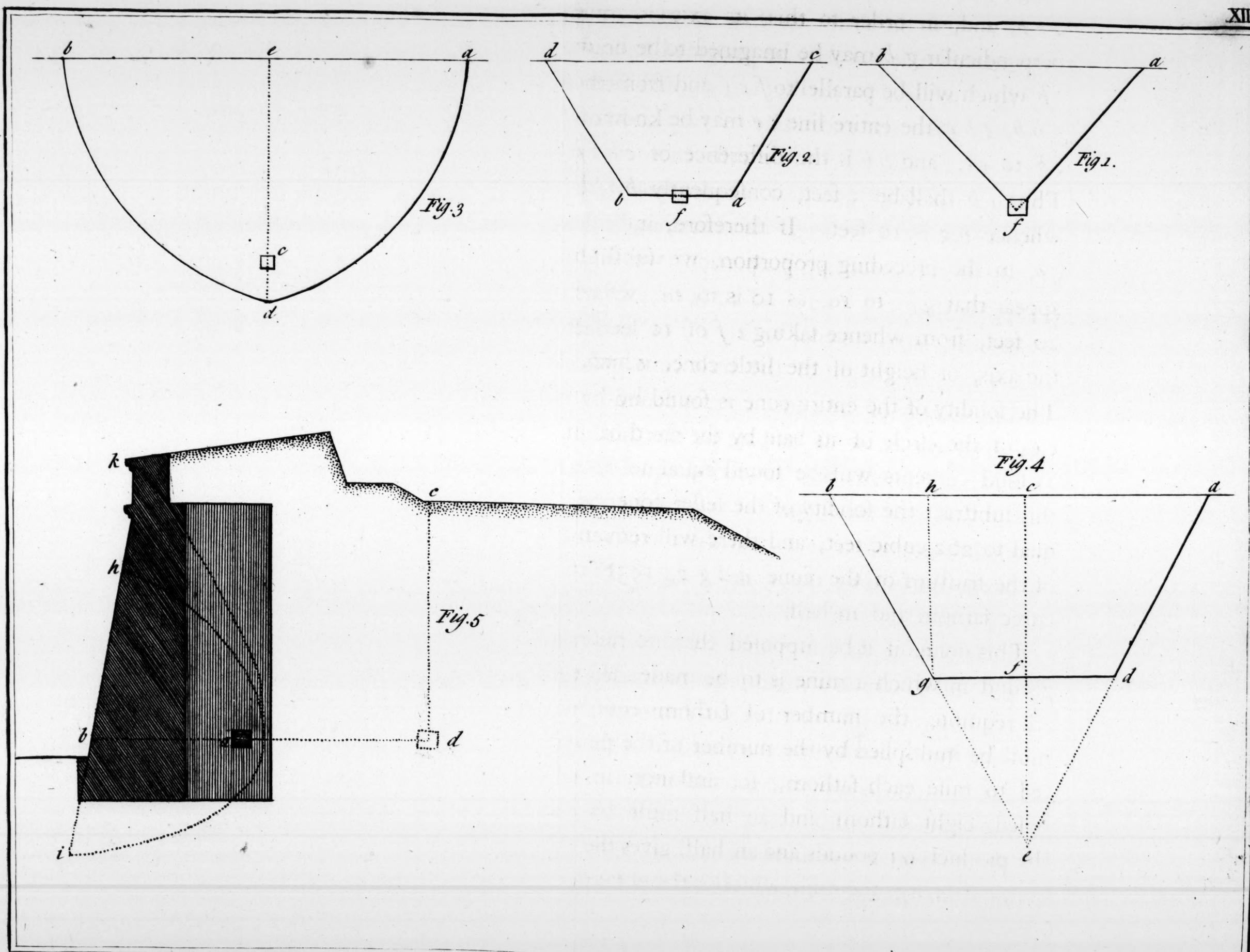
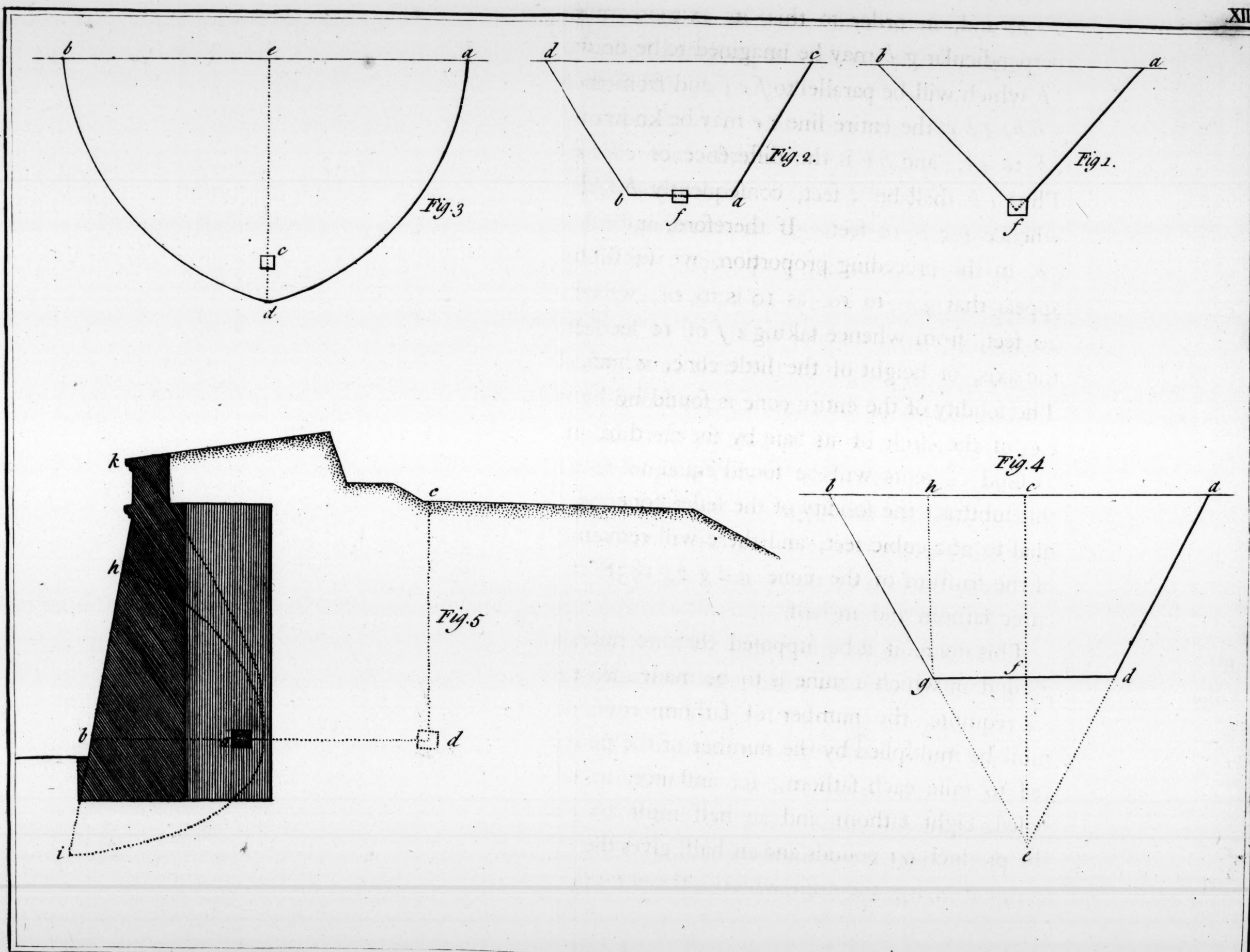
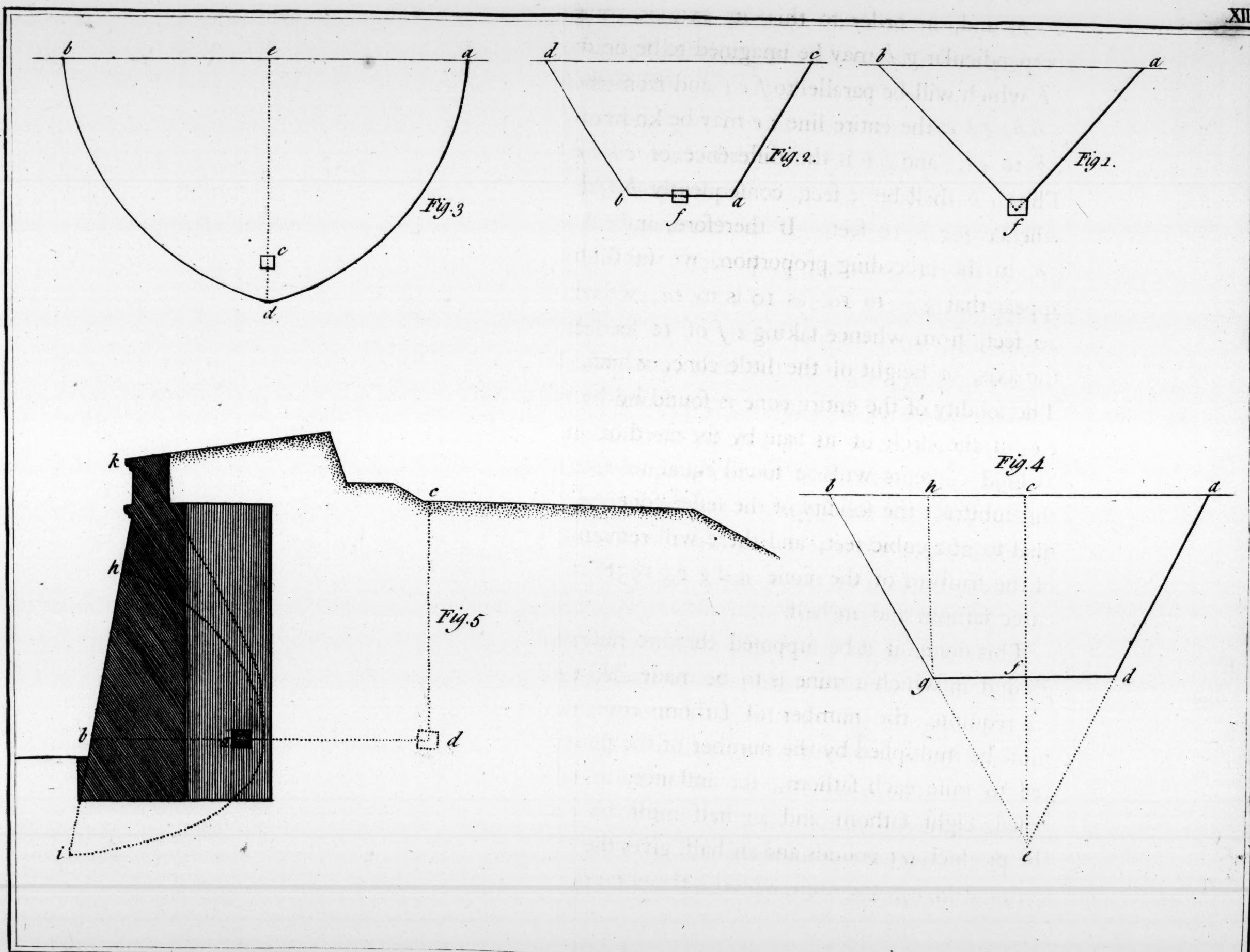
PL. XIII.
Fig. 4.

Of M. of the frustum of the cone, equal to the half of that of the larger circle, viz. 5 feet.

This premised, to find the cubic solidity of the frustum of the cone $a d g b$, it is necessary, first, to find the contents of the whole cone $a e b$, and, in order to this, its axis $e c$ must be known. The perpendicular $g b$ may be imagined to be drawn from g , to the line $c b$, which will be parallel to $f c$; and from the two similar triangles $g b b$, $e b c$ the entire line $c e$ may be known, for $b b$ is to $b g$, as $c b$ to $c e$, and $b b$ is the difference of $c b$ from $c h$, equal to $f g$. Thus $c b$ shall be 5 feet, consequently $b b$. $b g$ is equal to $c f$; whence $b g$ is 10 feet. If therefore, instead of the lines $b b$, $b g$, $c b$, in the preceding proportion, we substitute their values, it will appear that 5 is to 10, as 10 is to $e c$, which will be found to be 20 feet, from whence taking $c f$ of 10 feet, there will remain $f r$ the axis, or height of the little cone, which will also be 10 feet. The solidity of the entire cone is found by multiplying the superficies of the circle of its base by the third of its height $c e$, whence its solid contents will be found equal to 2100 cubic feet. From this subtract the solidity of the lesser cone, which will be found equal to 262 cubic feet, and there will remain for the solid contents of the frustum of the cone $a d g b$, 1838 cubic feet, or about 8 cubic fathom and an half.

This done, if it be supposed that, to raise a cubic fathom of the ground in which a mine is to be made, eleven pounds of powder are requisite, the number of fathoms contained in the excavation must be multiplied by the number of the pounds of powder required to raise each fathom; for instance, in the example just proposed, eight fathom and an half must be multiplied by 11, and the product, 93 pounds and an half, gives the quantity of powder requisite to charge the mine, which is the point in question. This quantity





may may be furthering augmented, that the effect of the mine may be
 that greater than it is, and to allow for the various accidents which
 may also happen to the powder in the chamber, to diminish its action.
 If the quantity of this mine had been calculated on the suppo-
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tity may be something augmented, that the effect of the mine may be rather greater than less, and to allow for the various accidents which may also happen to the powder in the chamber, to diminish its action.

If the excavation of this mine had been calculated on the supposition of its being a paraboloid, its solidity would have been found (5) 1890 cubic feet, which amounts to 8 cubic fathom and three quarters, that is to say, this solid would have been found about one fourth of a fathom larger than supposing it the frustum of a cone; which is a circumstance of little or no consequence.

When the quantity of powder requisite to charge the mine is known, what ought to be the dimensions or capacity of its chamber is to be thence ascertained.

The chamber must be of a size just to contain the charge it is to receive, that the powder being more confined, may, when inflamed, have a stronger effect. It must also be of the figure of a cube, that is, a solid terminated by six equal squares, because the powder taking fire in the middle of this solid, acts more equally on all parts of the chamber of the mine, than if it had any other figure, except it could be made circular, which would be still better, but the construction of it in this figure is too difficult.

The proper dimensions of the chamber may be easily determined by geometry, knowing only the weight of a cubic foot of powder which is found to be about 80 pounds; as, for instance, if a mine is to be charged with 80 pounds of powder, its chamber must be equal to one cubic foot. It may however be made about one third larger

(5) The solid contents of this paraboloid would have been obtained by multiplying the superficies of the circle of its base by the half of the line de , *Fig. 3.* which is called its axis. In order to have this line entire, the distance cd of the focus c from d , the summit of the curve,

must be known; for which purpose the line cb , or cd , must be drawn, and afterwards continued to ec , and the half of its excess above ec will be cd , which must be added to this line, to have the entire depth of the paraboloid, of which adb is the profile.

larger than the space filled by the powder, because, to prevent the powder from growing damp in the chamber, or furneau, it is covered all round with sacks, planks, straw, &c.

To fix then the proper dimension of the chamber of the mine for which we have above ascertained the proper charge, let us suppose, that to 93 pounds and an half, the quantity given by the calculation, 7 pounds and an half be added, there will then be 100 pounds compleat for the charge.

Now if 80 pounds of powder occupy 1 cubic foot of space, 100 pounds will occupy 1 cubic foot and one quarter; add to this 3 quarters of a foot for the sacks, planks, straw, &c. which are to be placed in the mine, and 2 cubic feet will be given for the total capacity of the chamber. So that nothing more is requisite than to find the side of a cube containing 2 cubic feet, which appears, by approximation, to be about 1 foot 3 inches; and then giving for the base of the chamber, a square whose side is equal to that just found, and making its height also equal to the same, it will have exactly the dimensions required. It may not be amiss to observe, that a rigorous exactness is not absolutely necessary in this sort of calculations.

We shall add here a table, calculated by M. de Valliere, which contains the quantity of powder requisite for the charging of mines, from one foot of the line of least resistance to forty.

A TABLE

A TABLE

*For the charging of Mines ; calculated by M. de Valliere,
Lieutenant-General of the King's Armies, and In-
specter-General of the Schools of Artillery.*

<i>Length of lines of least resist- ance.</i>			<i>Quantities of powder the mines ought to be charged with.</i>			<i>Length of lines of least resist- ance.</i>			<i>Quantities of powder the mines ought to be charged with.</i>		
Feet.			Pounds.	Ounces.		Feet.			Pounds.	Ounces.	
1	-	-	0	-	2	21	-	-	868	-	3
2	-	-	0	-	12	22	-	-	998	-	4
3	-	-	2	-	8	23	-	-	1140	-	10
4	-	-	6	-	0	24	-	-	1296	-	0
5	-	-	11	-	11	25	-	-	1558	-	9
6	-	-	20	-	4	26	-	-	1647	-	12
7	-	-	32	-	2	27	-	-	1815	-	4
8	-	-	48	-	0	28	-	-	2058	-	0
9	-	-	68	-	5	29	-	-	2286	-	7
10	-	-	93	-	12	30	-	-	2530	-	4
11	-	-	124	-	12	31	-	-	2792	-	4
12	-	-	162	-	0	32	-	-	3072	-	0
13	-	-	205	-	15	33	-	-	3369	-	1
14	-	-	257	-	4	34	-	-	3680	-	12
15	-	-	316	-	4	35	-	-	4019	-	8
16	-	-	324	-	0	36	-	-	4374	-	0
17	-	-	460	-	9	37	-	-	4748	-	11
18	-	-	546	-	12	38	-	-	5144	-	4
19	-	-	643	-	0	39	-	-	5561	-	2
20	-	-	750	-	0	40	-	-	6000	-	0

We

Of Mines

We have observed, that the powder pressing equally on all sides makes its greatest effort on the side where it finds the least resistance, so that its greatest effort may be directed to any side by forming it so as to afford an easier vent to the powder than the others.

PL. XIII.
Fig. 5.

Let *Fig. 5.* be the section, or profile, of a rampart 30 feet high; if the chamber of a mine be placed in the ground it stands upon at *d*, so as that the line of least resistance, *cd*, is less than the distance *bd*, that is, less than that of the chamber from the exterior part of the wall, it is evident, that the mine will spring towards *c*, and not towards *b*; but in attacking places, mines are used chiefly to destroy the wall, or rampart, and with great success. To answer this purpose, the chamber of the mine must be so placed as to have the desired effect; for instance, in *a*, where the distance *ab*, from the chamber *a*, is less than that of all the other exterior parts of the rampart and its facing. We have supposed in this example the height of this facing *bk* 30 feet; so that if the chamber be made at the distance of 12 or 15 feet from the exterior side of the revêtement, or facing, the effort of the mine will be made by *bai*; and as the part of the ground *i* will resist this effort, it will be wholly directed to *bk*, and by that means blow up the revêtement into the ditch. The quantity of powder requisite to produce this effect may be determined, by the method above laid down, or measuring the solid *bai*, and multiplying the number of fathoms contained in it by 20 or 25, the quantity of powder necessary to raise one cubic fathom of masonry, and then adjusting the capacity of the chamber to the quantity of powder it is to receive, by the directions contained in what has been said above upon the subject.

SECT. IV. *New Observations and Experiments for perfecting the Calculation of Mines.*

WHAT has been said already contains in general the method, at present used, for calculating the quantity of powder requisite for the charging of mines. But M. *Belidor*, who for a long time, with great reputation, professed mathematics in the school of artillery at *La Fere*, has observed, in a particular tract inserted in his *Cours de Mathematique*, that it is not sufficient to consider only the weight and quantity of earth intended to be raised by a mine, but that regard must also be had to its quality, with respect to its consistence, and the cohesion of its parts *; and as this cohesion is greater in small solids, in proportion to their cubic contents, than in large, more powder is requisite to raise or blow up each cubic fathom of a small solid body, than of a large; and it is evident that this observation must introduce a greater degree of exactness in the calculation of mines.

To be easily convinced that a small solid has more surface, in proportion to its cubic contents, than a larger, it is only necessary to compare a cube, the side of which is one foot, and consequently its body terminated by six squares of one foot each, with another cube the side of which is two feet. The solid contents of this last body are eight times that of the first; for the superficies of its base is the product of 2 multiplied by 2, which is 4, and its solidity the product of the base multiplied by its height, viz. of 4 by 2, which is 8; so that the last solid is 8 times larger than the first. If the superficies augmented in proportion to its solidity, this also would be 8 times that of the first, whereas it appears to be but 4

M times

* M. *de Valliere* also takes notice of the same thing, in the dissertation mentioned in a former note.

times as large, because each square of the superficies of this solid contains but 4 squares of one foot each, so that, with respect to its solidity, or cubic contents, its superficies is less than that of the cube whose side is but one foot.

It is then plain that the greater the solid intended to be raised is with respect to its superficies, the more difficult it will be to move it from its bed, which evidently shows the necessity of considering the tenacity of earths in the calculation of mines.

M. *Belidor* proposes in the same tract several experiments for the discovery of this tenacity. He directs that 3 or 4 mines be made in a soil of the same consistence, and of an equal depth, that is, having their lines of least resistance equal, and charged with a very moderate quantity of powder, just sufficient to shake or loosen the ground between the bottom of the chamber of the mine and the superficies of the earth, so that the extent of the shock may be seen in this superficies by tracing the circle made in it thereby. As it is only by trials many times repeated that the quantity of powder requisite to produce this effect can be exactly known, it is plain that many experiments must necessarily be made before this quantity is determined; but when a charge shall be ascertained just sufficient to move the ground, and break the continuity or cohesion of the solid intended to be raised with the rest of the ground, a charge will be obtained sufficient to overcome the resistance of the continuity of those parts; and this quantity being known for a line of least resistance of a given length, the quantity of powder, requisite to overcome this continuity in a mine having a line of least resistance of a different length, may be ascertained by geometry.

Those who are acquainted with the elements of geometry know that the superficies of similar solids are to each other as the squares of their homologous sides. All solids raised by mines made in
earths

earths of the same kind, whatever their figure may be, are similar, and have their lines of least resistance homologous, or in similar proportion: it follows then that their superficies are to each other as the squares of the lines of least resistance. Hence if it is supposed that 50 pounds of powder have loosened the earth of a mine of which the line of least resistance was 8 feet, and it is demanded how much would be requisite to produce the same effect in a mine of which the line of least resistance should be 12 feet, this question may be answered by the rule of three in this manner, by saying, as the square of 8, which is 64, is to the square of 12, which is 144, so 50 pounds of powder are to the 4th term, which will be about 112; and thus it will appear that 112 pounds of powder are requisite to surmount the continuity of the earth, in a mine of which the line of least resistance shall be 12 feet.

Now in order to know the quantity of powder necessary to raise the earth of the mine, nothing more is necessary than to charge many in the same soil, having their lines of least resistance equal, and spring them with different quantities of powder, till the charge is obtained, which produces the effect desired on the tunnel of the mine.

This charge found, the quantity of powder necessary to produce the same effect in a mine, of which the line of least resistance shall be different, may be thence discovered. And to effect this, those acquainted with the elements of geometry need only remember that similar solids are to each other as the cubes of their homologous sides, and that by the same rule the solids blown up by mines are to each other as the cubes of the lines of least resistance.

Hence, if 70 pounds of powder have produced the desired effect in a mine of which the line of least resistance was 8 feet, in order to find the quantity of powder necessary to produce the like

effect in a mine of which the line of least resistance shall be 15 feet, a rule of proportion must be formed in this manner: as the cube of 8, which is 512, is to the cube of 15, which is 3375; so is 70 pounds of powder, the charge of the first mine, to the quantity of powder requisite to charge the mine in question, which will appear to be 461 pounds; but this quantity will be a little too strong, because it is founded on the supposition that the tenacity of the ground of this mine was proportioned to its mass, whereas we have shewn it to be less.

To find the quantity necessary to be taken from it, it must be considered, that the mine, of which the line of least resistance was 8 feet, required 50 pounds of powder to surmount the tenacity of the earth; and that as the same mine blew up and made the excavation desired with 70 pounds of powder, there was consequently but 20 pounds of powder employed in blowing up the earth. Hence then may be deduced both the knowledge of the quantity of powder necessary to break the continuity of the mine of which the line of least resistance is 15 feet, and the quantity necessary to blow it up.

First, to find its continuity, this rule of proportion must be formed, founded on what has been said above: as the square of 8, which is 64, is to the square of 15, which is 225; so is 50 pounds of powder to the fourth term, which will be found to be 175 pounds; and this is the quantity of powder requisite to break the tenacity of a mine whose line of least resistance is 15 feet.

In the second place, the quantity of powder necessary to spring this mine may be found by this other rule of proportion, founded also on what has been said before.

As the cube of 8, which is 512, is to the cube of 15, which is 3375; so is 20 pounds of powder to the quantity of powder required,

quired, which will be found to be 130 pounds; this quantity being added to that necessary to break the tenacity, which was found to be 175, the total will give 306 for the quantity of powder necessary to charge the mine in question. By all which it appears that if no regard had been had to the less degree of tenacity of this last mine, allotting it 461 pounds of powder (which is the quantity given by the first calculation) it would have been charged with 155 pounds too much.

The above-mentioned experiments, made in earths of different consistencies, will furnish materials for tables exact enough for the charging of mines, with this great advantage, *viz.* that the figure of the solid is out of the question; for let this be what it will, it can cause no error in the calculation.

The Court, pursuant to what we have related from M. *Belidor*, having thought proper to cause these experiments to be made, as tending much to the improvement of the doctrine of mines, they were made accordingly, and M. *Belidor* has promised to give them to the publick, with a compleat treatise on this subject, in which will undoubtedly be found many things entirely new, and of great moment.

These experiments remove a very singular prejudice founded on those already mentioned to have been long since made at *Tournay*, *viz.* that the force of the charge of a mine never enlarges the tunnel, but on the contrary diminishes its opening, insomuch that when sprung with powder, the mine shall form only a kind of pit, the mouth or superior opening of which shall be little larger than the chamber of the mine. The contrary of this has appeared from newer experiments(6): for by increasng the charge of the mine

(6) In 1729 at *La Fere* seven galleries or consistence, and upon the same plain, were made in a soil of the same nature or level. They terminated at bottom in a pit

mine a larger excavation has been produced, and always in proportion to the charge ; from whence an inference may be made of great importance in the attack and defence of places, *viz.* that the quantity of powder may be ascertained requisite to give the mine an opening of a determined magnitude ; for example, of 6, 8, and 12 fathom. But in spite of those experiments M. *Bigot de Morogues* remarks, in his *Essay on Powder*, that “ this subject is still disputed among miners, who continue to make it a question whether a furnace overcharged produces only a tunnel in form of a pit, or if, in spite of prejudice, it makes one of a diameter much greater than double the line of least resistance.” And he adds, “ Reason vouches, theory shews, and experience confirms both opinions in the judgment of their several advocates.”

As it appears from these experiments that the common supposition, that the radius of the outer circle of the tunnel is equal to the line of least resistance, is not exactly true, any more than that the radius of its inner circle, or that at the bottom of the tunnel, is equal to the half of the line of least resistance ; it thence follows, that the calculations founded on these suppositions are not more certain. However the mines which have been sprung, according to the present calculations upon these principles or suppositions, have notwithstanding produced the effect proposed, which seems to evince

a pit of 10 feet in depth, so that the furnace of each gallery had a line of least resistance of 10 feet. The first furnace was charged with 120 pounds of powder, the second with 160, the 3d with 200, the 4th with 240, the 5th with 280, the 6th with 320, and the 7th with 360 ; these furnaces having played, the diameter of the upper circle of the tunnel of the first was found to be about 22 feet, that of the 2d, 26, that of the 3d, 24, and those of all the rest increasing, the diameter of the last being 38 feet 6 inches ; as to the

diameter of the circle at the bottom of the tunnel, it has been found in mines, having lines of least resistance of 10 feet, to be much less than that line ; among others, in a mine having its line of least resistance 10 feet, and charged with 1000 pounds of powder instead of 93, which was its proper charge, the diameter of the bottom of the tunnel was found to be no more than 5 feet. It is presumed that with the common charge it would have been still much less.

evinced their truth and exactness. But the reason of this is, that as the solid to be raised by the mine is supposed to be a little bigger than it really is, the furnace of the mine is consequently something overcharged with respect to this solid, which they are not apprized of, and for this reason the mines never fail to succeed, and produce even a greater effect than is expected from them.

It is then natural to enquire what advantages in mining may be drawn from the above experiments; these M. *Belidor* will doubtless enumerate particularly, in the *Treatise of Mines* which he has promised to the publick, but in the mean time we shall point out several which seem to be of considerable importance.

It is the present practice, in order to spring a mine which shall produce an opening, for example, of 40 feet, to sink it 20 feet below the surface of the ground, that it may have a line of least resistance of that length. As all earths will not admit of this, an excavation of 40 feet diameter cannot be made by one mine, or one furnace, where there is not this depth of earth; so that in this case it becomes necessary to make several. In the attack, but more especially in the defence of places, there are many cases in which a mine that gives too deep a tunnel serves only to furnish a covert to the enemy; but this could never happen if it were possible to give a tunnel of less depth, and at the same time of a larger diameter. Besides, the less deep the tunnel, the oftner the furnace might be repeated in the same place. Add to this, that in the major part of places where mines are employed, the celerity of their construction is a point of great importance; therefore if, without sinking the mine so deep as is practised at present, they could be contrived so as to produce the same effect, the execution of them would be sooner performed, and consequently to much greater advantage.

After

After having given some idea of the sentiments hitherto held concerning mines, it is necessary to say something of their construction, and that of their galleries.

SECT. V. *Of the Construction of Mines and their Galleries.*

WE shall say nothing here of what concerns the miner, *viz.* of the manner in which he breaks ground, and carries on the trenches, deferring this till we come to treat of the attack, where the difficulties he meets with in the course of his work will be particularly considered.

The galleries which are made and carried on by miners, till they come under the place intended to be blown up, are commonly four feet and an half in height, and two feet and an half or three feet wide.

The miner works upon his knees, he begins by making an hole big enough to hold himself, another miner is placed behind him, who gathers up, in a kind of little wheel-barrow, the earth which the first miner digs out in making his passage. This wheel-barrow is sometimes fastned to a cord, so contrived as that when it is full, a miner, who is posted at the end of the gallery, can draw it to him, and empty it of the earth without the gallery, and when it is thus emptied, the second miner can draw it back to be filled again. But this is done only when the gallery is not carried on far in the earth; when it is, many hands are employed to clear away the ground dug out from the gallery. Miners relieve each other every two hours, and carry on their work with the greatest possible diligence and expedition.

As the gallery advances, the carpenters are appointed to shore it,
that

that is, to set up at proper distances pieces of timber, called *props* or *shorings*, to sustain the earth above the gallery, and prevent its falling in; sometimes small arches are formed of several pieces of wood for this purpose, and sometimes they content themselves with laying planks supported by the props, which last is the method commonly used.

The miner carries on his work till he comes to the place where the chamber is to be made, and when he has given this its proper dimensions, the carpenters shore it; it is then lined with empty sacks, straw, and plank, to prevent the powder from growing damp; and when it is in every respect compleated, the powder is laid on the planking upon a bed of straw, covered with empty sacks; the end of the sausage is placed in the middle of the powder, that it may all take fire at once. That the sausage may continue fixed in this position, it is pinn'd to the interior part of the chamber, near the planks supported by the shorers, with a wooden peg, which secures it. This peg has also a further office, which is, to prevent the sausage from being drawn out of the chamber of the mine. That part of the sausage which lies out of the chamber in the gallery, is placed in a trough or gutter, as mentioned before.

The top of the chamber is cover'd with strong planks, upon these props are placed, which support other planks, that prevent the earth of the gallery over the chamber from falling in; pieces of wood are also laid horizontally crossing each other at right angles, or obliquely in the form of St *Andrew's* cross; these serve to hold the props more firmly against the earth of the gallery. The void spaces are then filled with dung, brick, stones, and other things of the like kind; a great part of the gallery is also filled with these materials, to prevent the powder from evacuating that way.

That the gallery may oppose a resistance effectual to prevent the

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powder

PL. XIV.
Fig. 2.

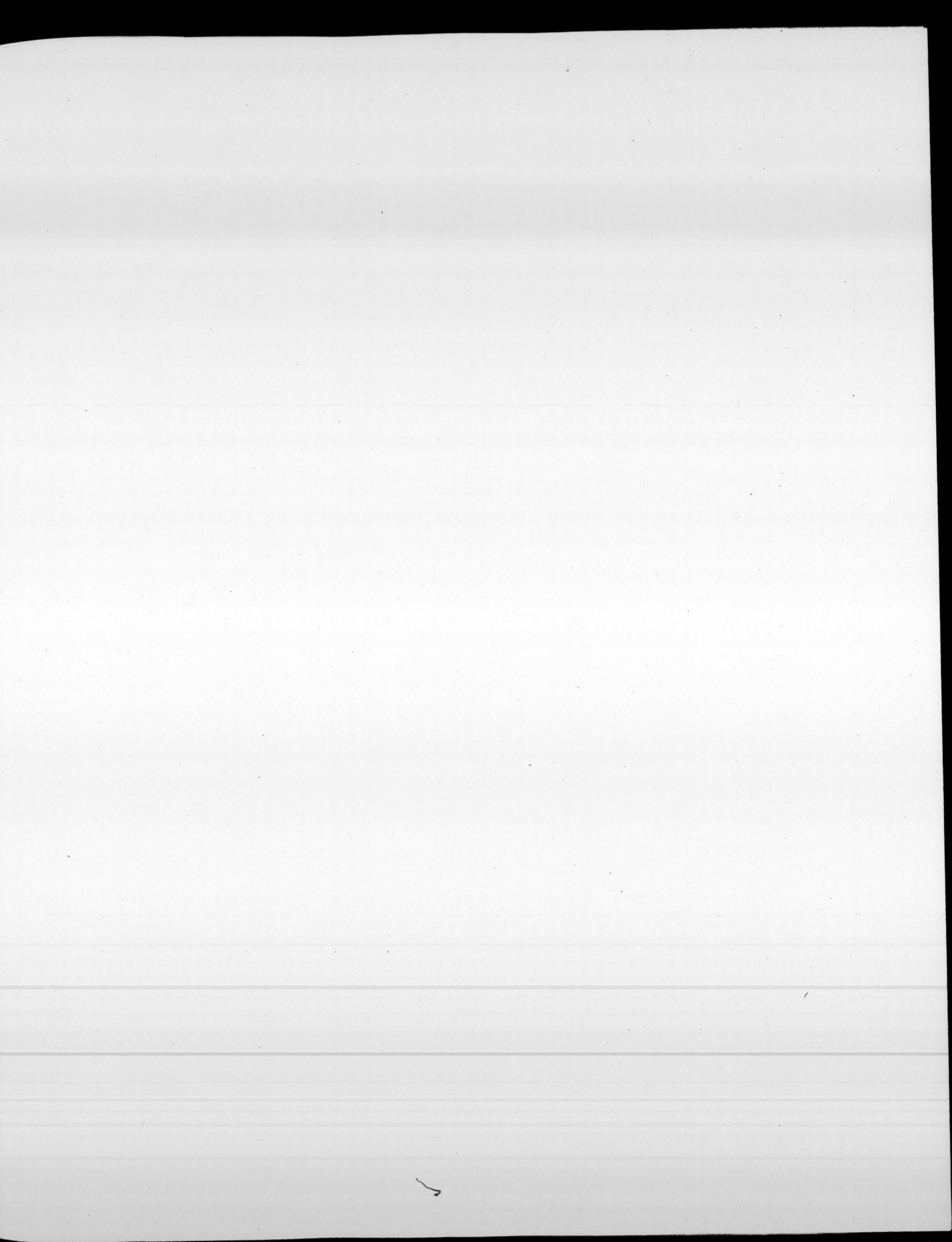
Of Mines powder from evacuating by it, it is necessary it should be longer than the line of least resistance of the chamber of the mine.

PL. XIV.
Fig. 1. For if b is supposed to be the chamber constructed in the contre-fort; a and c , the entrance of the gallery over against the chamber b ; as its length, bc , is much less than the height of the ground and the masonry above the chamber, however carefully and exactly this gallery may be filled and stopped up, its resistance will not be equal to that of this earth and masonry; and therefore the mine will take effect principally by the way of the gallery, or, as miners generally term it, the mine will blow in the gallery.

PL. XIV.
Fig. 2. But if, to blow up part of the rampart overagainst and above the point l , the opening or mouth of the mine be made in d , at a proper distance from this part, and the gallery be conducted by returns, or as it were elbowings, from d to e , from e to f , from f to g , and lastly, from g to i ; it is evident that a part of the gallery may be filled or stopped up, sufficient to oppose a stronger resistance to the powder inclosed in the chamber, than will be made by the line of least resistance, and that in this state the mine may be made to produce all the effect that is desired.

From hence it follows, that to blow up part of a rampart, or revêtement, the gallery ought to be opened at some distance, and conducted to it by returns, or traverses. These traverses, or returns, are of considerable use in facilitating the effectual stopping up the gallery; but as they prolong the work, no more of them are made than are thought necessary to make the gallery resist the powder more forcibly than the line of least resistance of the mine.

PL. XIV.
Fig. 3. To give some idea of the manner in which a gallery is filled at each coude or return, let $abcd$ be one of these returns or coudes; to fill this up, madriers or planks are first placed vertically along cd ,



On the contrary, it is not by its own resistance of the light, but by its own resistance to the entrance of the light, that it is made to be a light.



Fig. 1.

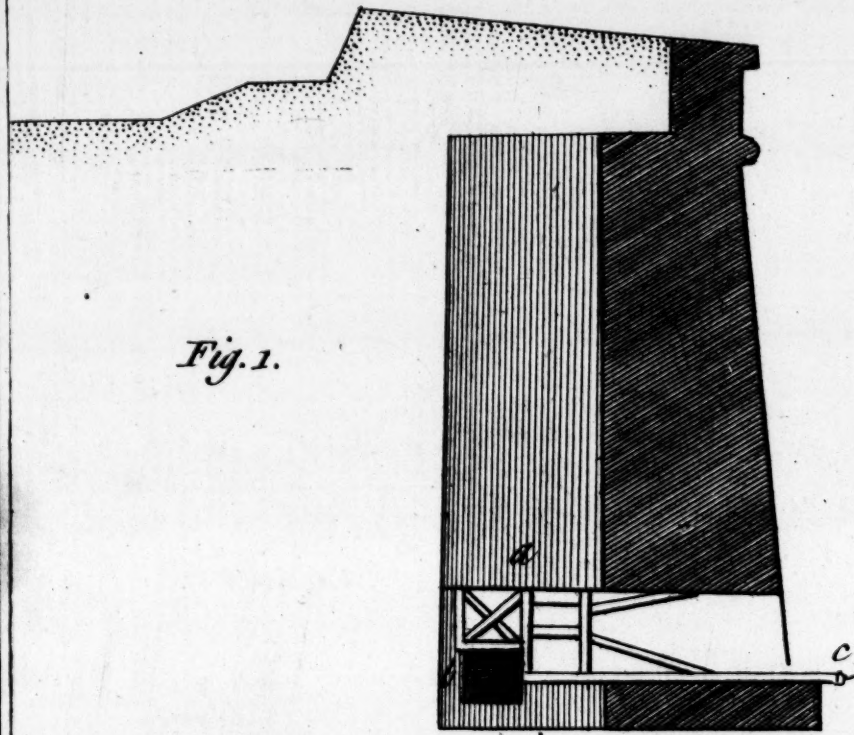


Fig. 2.

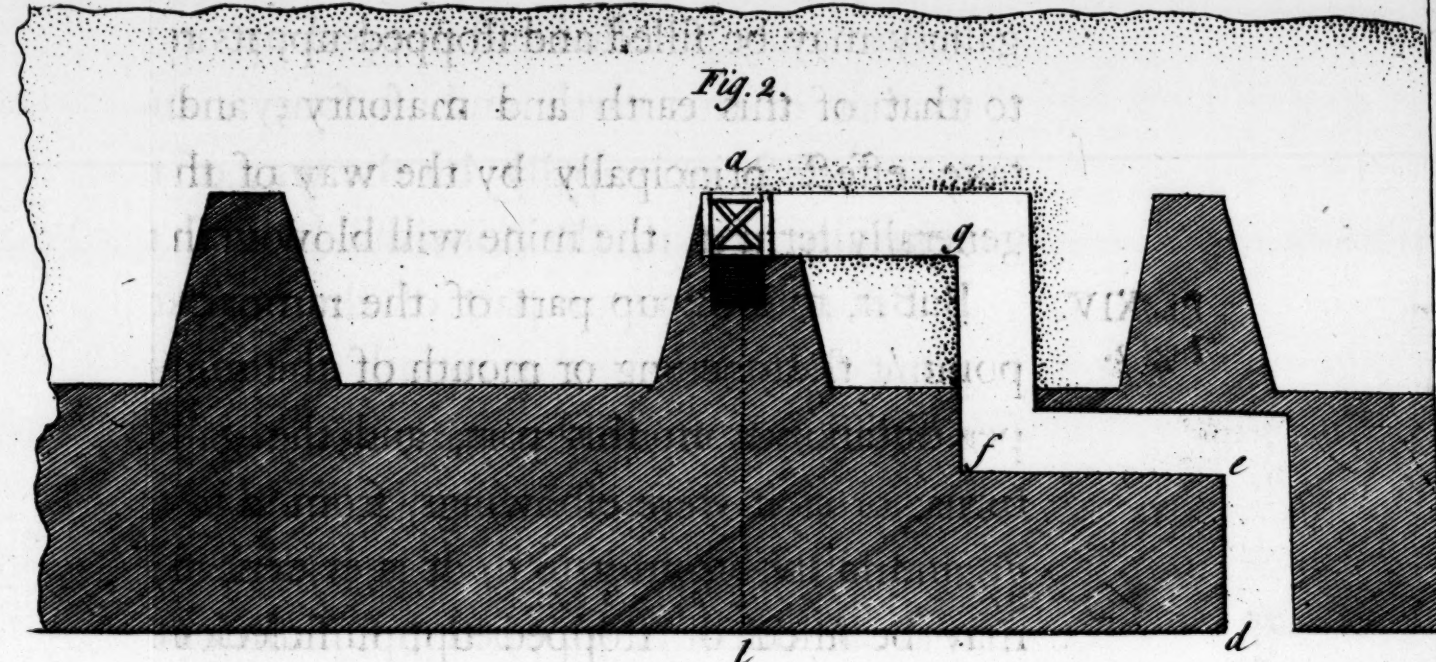


Fig. 3.

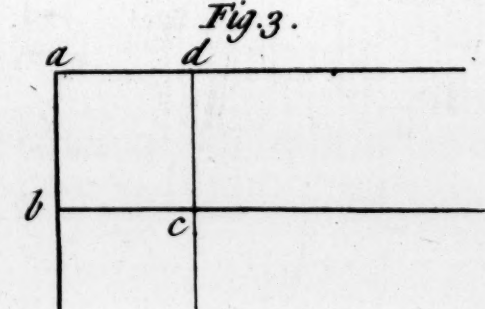


Fig. 4.

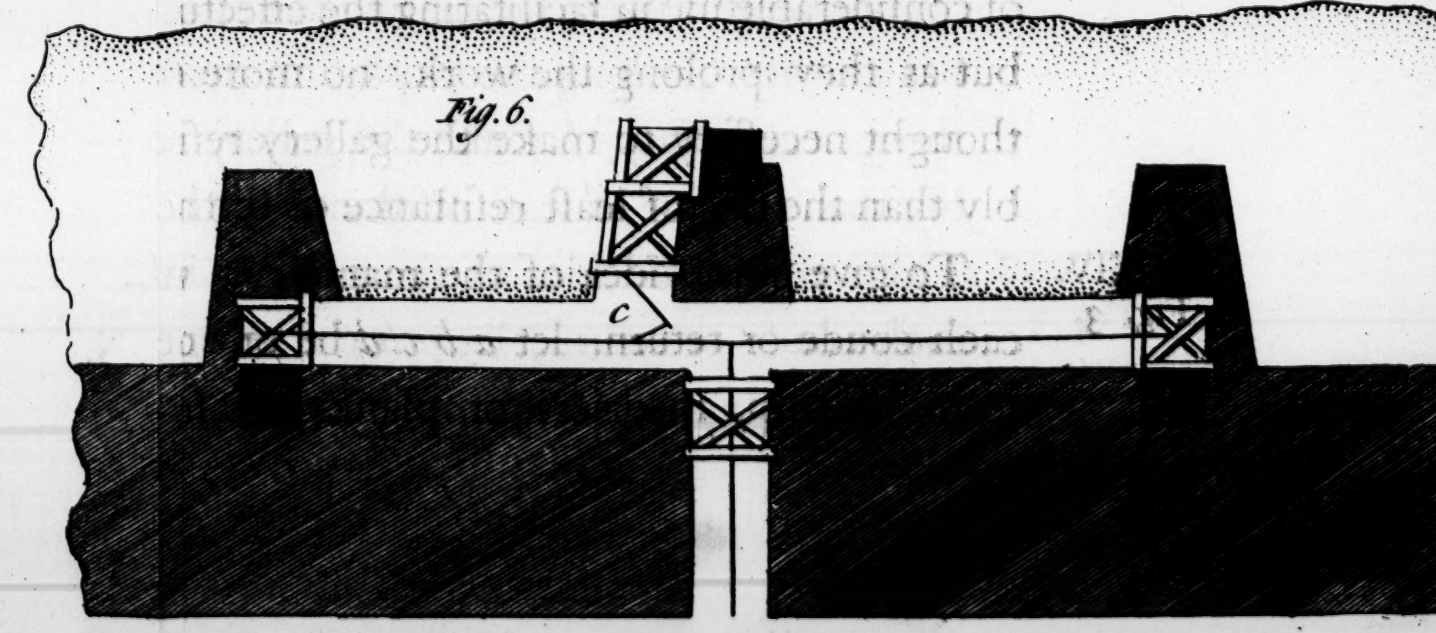
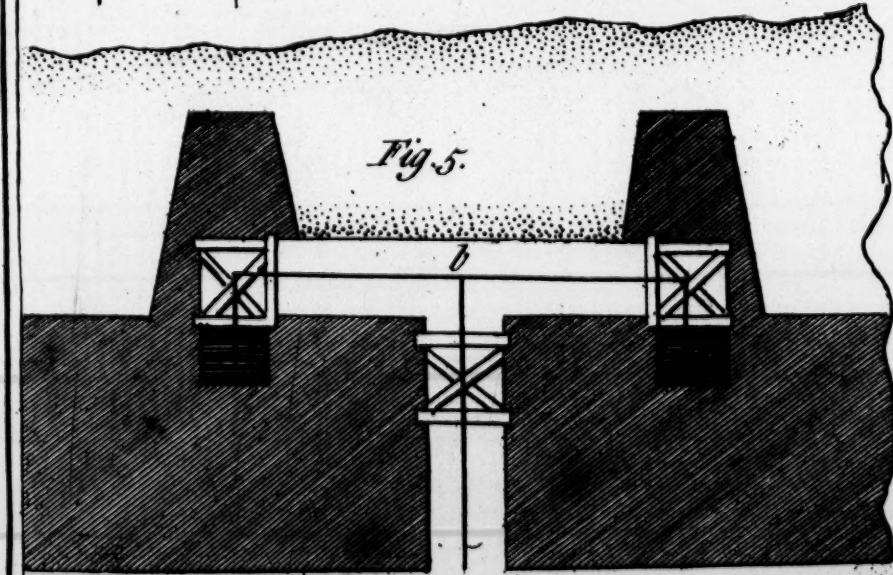


Fig. 5.



and in the same manner along a b; these planks are then covered with others laid horizontally, those marked c & d terminating towards e and f, and those marked a & b towards e and f. On the back of these machines, to support and strengthen them, pieces of wood, called *traversees*, are set up vertically, and made to bind tight on both sides of the machines a and b, by strong pieces of wood laid transversely, called *battres*. And that these pieces of wood may press as forcibly as possible on the machines, which are backed or supported by the *piedroits*, they are driven in with great force, and strong wedges are placed between the extremities of the *battres* and the *piedroits* on which they rest, and the void space of the *coude* is filled up with the same material, used for filling the spaces above the chamber of the mine.

It must be noted, that the whole length of all the remains of the gallery together, does not express the resistance which it makes to the effort of the mine; for the powder expanding circularly, a gallery of many *coudes*, or traverses resists this effort only in proportion to the length of the supposed right line, reaching from the opening or mouth of the chamber, which line may be considered as the length of the gallery, and it is by this that the length of the gallery is expressed or measured.

Let a be the distance of a mine, of which the face of half resistance is at a, and b the distance of the gallery a, and c & d taken together are equal to the length of the gallery, and if the gallery is supposed to be filled with powder, the whole of the line degree of resistance is the ground or matter, which the powder will expand towards the opening of the gallery, and is preserved above, in the direction of the line a b, which

Pl. XIV.
Fig. 4.

$c d$, and in the same manner along $a b$; these planks are then covered with others laid horizontally, those marked $c d$ terminating towards c and d , and those marked $a b$ towards a and b . On the back of these madriers, to support and strengthen them, pieces of wood, called *piedroits*, are set up vertically, and made to bind tight on both sides of the madriers $d c$ and $a b$, by strong pieces of wood laid transversely, called *buttreffes*. And that these pieces of wood may press as forcibly as possible on the madriers, which are back'd or supported by the *piedroits*, they are driven in with great force, and strong wedges are placed between the extremities of the *buttreffes* and the *piedroits* on which they rest; after this the void space of the coude is filled up with the same materials used for filling the spaces above the chamber of the mine.

It must be noted, that the whole length of all the returns of the gallery together, does not express the resistance which it makes to the effort of the mine; for the powder expanding circularly, a gallery of many coudes or traverses resists this effort only in proportion to the length of the supposed right line, reaching from the opening or mouth of the chamber, which line may be considered as the length of the gallery, and it is by this that the length of the gallery, is expressed, or measured.

Let b be the furnace of a mine, of which the line of least resistance is $a b$; if the sides of the gallery $b c$ and $c d$, taken together, are equal to the line $a b$, and if the gallery is supposed to be filled with materials capable of the same degree of resistance as the ground or materials of the line of least resistance, the mine will spring by its gallery; for the powder will expand towards the opening of the gallery d , as we observed above, in the direction of the line $b d$,

PL. XIV.
Fig. 4.

Of Mines which is less than the lines bc and cd taken together, and consequently less than the line of least resistance, therefore, &c.

It follows from hence that the part of the gallery which is to be filled, ought not to be estimated by the length of the several parts or returns of the gallery, but by a right line drawn from the centre of the chamber to a certain point of the gallery. Geometry furnishes a great number of rules for the measuring of this line; that which appears to be the most simple is, to trace very exactly all the returns of a gallery upon a plain by means of a scale, after which it will be very easy to discover, by the same scale, the points of the gallery on which a right line of a determined length, drawn from the centre of the chamber through the gallery, will fall.

The materials with which a gallery is filled cannot be cemented or bound together, so as to give them a solidity equal to the parts of a fortification, or the old masonry. But when works of this nature are to be blown up, the gallery is to be so filled, that the right line, by which the length of the part filled up is expressed, may be longer than the line of least resistance. It is very difficult to give precise rules in this particular; some authors have nevertheless maintained that in common earth the gallery need only be filled up about 5 or 6 feet more than the line of least resistance, and that in masonry it must be filled one third or one half more than this line; so that if in the last case the line of least resistance is 18 feet, the gallery ought to be filled up 24 or 27 feet at least; and it is to be noted, that this length is always to be reckon'd on the right line supposed to be drawn from the chamber to the end of the gallery.

Nothing more remains, after what has been said above concerning mines, but to give some idea of the several kinds of them.

SECT. VI. *Of the different Kinds of Mines.*

A Mine which has only one chamber, or fourneau, as the mine *a*, is called a *simple* mine. If it has two chambers, as represented by figure *b*, the gallery forms a sort of T, and the mine is called a *double* mine. If it has three chambers, as in *fig. c*, it is called a *triple* mine; and, lastly, if it has four chambers, it is called a *quadruple* mine, always taking its name from the number of its chambers or fourneaus.

PL. XIV.
Fig. 2,
5, 6.

The design of mines which have many chambers, is to blow up at the same time a great part of a rampart, or a large extent of ground. Such a disposition is observed in their distances, or intervals, as that they may co-operate together; and their several charges are all fired at the same time, by means of a faufage communicating with all the chambers, the faufage being fired in such a part as that the fire may reach all the chambers at the same instant. To produce this effect, it is only necessary that the fire should run through equal lengths of the faufage from the point where it is fired, called its *focus*, to the centre of each chamber, so that if some chambers be nearer the focus than others, the faufage must be laid in returns or zigzags, that it may have the same length between the focus and the nearer chambers, as between the focus and those which are at a greater distance.

In revêtements, where the mine is intended to be constructed double, the gallery must be opened between two contreforts, and the revêtement being pierced, it must be pushed on to the right and left along the outside of the revêtement to the middle of two contreforts; and being brought thus far, the chambers are hollowed out in that part of the revêtement joining to these contreforts.

To

A TREATISE of

To make a triple mine, the gallery is opened overagainst a contrefort, and when the opening of the revêtement is pierced, it is extended to the right and left, as in the double mine, to the two next contreforts, and here the chamber is made in the revêtement in the same manner as in the double mine. A gallery is also carried on to the side of the contrefort, which is overagainst the opening or mouth of the mine, and behind this contrefort the third chamber is made, as it appears in *Fig. c.*

PL. XIV.
Fig. 6.

As to quadruple mines, they are only two double mines, joined together by the same saufage.

The simple and double mines are most used in sieges, the others being seldom made but when some work is intended to be totally demolished.

In the attack of places it is common to make little mines, the chambers of which are not deeper in the ground than from five to twelve feet. This kind of mine is called a *fougade*; and is commonly made under the faillant angle of the glacis, being double, triple, &c. in many places. The galleries of these mines, which are called their *branches*, are constructed before the attack of the place is thought of, and make a principal part of its fortification. Places which have galleries or branches constructed under their glacis, and in the parts adjacent, are said to have the glacis countermined. The citadel of *Tournay* has its glacis countermined, and many of the front-works of *Luxembourg* have the same.

With respect to the countermines of places, of which we have said nothing as yet in this treatise, it is sufficient to recite what has been said of them in our *Elements of Fortification*, viz. “that
“ they are subterraneous galleries, constructed at the same time with
“ the place, whether they reach within the bastion, or under the
“ fosse and covered way. Their use is to facilitate the meeting, and
“ pre-

“ preventing the enemy’s miners, to obstruct their works, and to
 “ furnish means, by continuing their branches, to blow up the e-
 “ nemy’s lodgments on the covered way and other works which
 “ he has gained.”

When the besiegers would make use of mines or fougades in an attack, the miner sinks some pits in the nearest places he can work in to the spot intended for the chamber, and from the bottom of these pits he advances his gallery or branch to the places which are pointed out to him.

Nothing now remains, after all that has been said concerning mines, but to observe that the use of them is very ancient, and that they were practised even in the remotest antiquity. Galleries were then made much in the same manner as at present, and when they were brought under the wall intended to be destroyed, a very large gallery was made in the body or thickness of the wall; that part of the wall directly over this gallery was sustained by strong props or shorers, and the gallery filled with combustibles, that is, such materials as took fire easily, and retained it long; these materials being kindled, communicated the flame to the props, which being soon consumed, the wall no longer supported by them fell in, and by that means made a breach in the place.* The besieged also made use of the like artifice against the besiegers, often making cavities under the machines of the enemy, which falling down into the excavation or hollow of the mine, were either broken to pieces, or at least rendered unserviceable for some time. By means of gunpowder mines are now made with much greater celerity than those of antiquity: since the discovery of this composition the old method of

* These props were also sometimes pulled away by means of cords fastened to them, and carried through the gallery, which answered the same end as destroying them by fire, with this advantage, that the smoke did not discover the design to the enemy.

Of Mines mining is in a manner entirely laid aside ; I say, in a manner, because it is still used in some cases, and the chevalier *de St Julien* reports that he actually saw a mine constructed in the ancient manner, made use of for destroying a work of the fortification which covered the castle of *Pont-a-Mousson*. But these examples are so rare, that the new method may be regarded as the only one at present in use.

The custom of charging mines with powder is less ancient than the application of it to other military purposes. The first essay of this kind was in 1487 ; the *Genoese* besieging *Serezanella*, a town belonging to the *Florentines*, an engineer attempted to blow up the wall of the castle with gunpowder placed under it ; but the effect not answering his expectation, probably either because he charged his mine with too small a quantity of powder, or because it made its effort by the gallery, no improvement of the hint of this engineer was thought of, till *Peter of Navarre*, who then served in the *Genoese* army, and was afterwards in the service of *Spain*, made use of it in 1503 against the *French* at the siege of *Castel del Ovo*, a sort of fort or citadel of the city of *Naples*. The commandant of this fort refusing to surrender at the summons of *Peter of Navarre*, he blew up the wall of the castle, and took it by assault.



Of the Fireworks most used in the Attack and Defence of Places.

FIREWORKS were much more used by the antients in the attack and defence of places, than at present.---The great and violent effects of our cannon, mortars and mines, which nothing can resist, seem to have been the cause of our neglecting many useful and ingenious contrivances of the antients, used reciprocally, to distress the enemy, both by the besieged and besiegers. Although they had not the use of powder, they made use of fire in almost an infinite number of different ways. The invention of powder, and its use, furnish many easy methods of incommoding an enemy by fireworks. It is not our present purpose to treat of all the compositions which may be made with gunpowder to annoy an enemy, but of the principal only, and those most commonly used.

The chief of these compositions are the fire-pot, the fire-ball, thundering-barrels, tarred faggots, the thundering herisson, or hedge-hog, torteaux, or torches, powder-sacks, grenado-balls, bomb-balls, and pebble-balls.

The fire-pot is nothing but an earthen pot with two handles, in which is put a charged grenado, and all the rest of the cavity filled with fine powder; it is covered with parchment or sheepskins, a match is fastened cross-ways on the pot, and another to its handles, which are lighted when the pot is to be thrown. This pot when it is thrown falls to the ground, and breaks to pieces, the matches

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Fire-balls at the same time firing the powder, and this again firing the grenado, the whole breaks into splinters, which causes much disorder among the troops where the pot falls.

Fire-balls are either round or oval, filled with different compositions, all difficult to be extinguished. These are thrown to a great distance with a mortar, and some of a less size are thrown by hand like granadoes. Their use is to give a light, by which an enemy may be discovered in the night, and fired upon with more certainty; they are also made use of to fire magazines of forage, and houses in a town which is attacked. And to prevent any one from coming near them, and attempting to extinguish the fire, they are filled, in the same manner as carcases, with grenadoes, and small ends of musket barrels, charged with bullets, which keep at a distance those who might otherwise throw something upon this firework to prevent its effect.

Thundering-barrels are common barrels, or casks, filled with a composition, and rolled upon the works of an enemy, in order to set them on fire, and drive him from the place intended to be attacked.

This firework is sometimes nothing but a barrel of common powder, in which a fuse is inserted, and fired before the barrel is rolled towards the enemy; this fuse fires the powder in the barrel, which by its explosion causes great disorder among the troops where it takes effect.

The *tarred faggot*, or fascine, is a kind of common faggot very well soaked in tarr, and which, like the thundering-barrel, serves to burn the works upon which it is thrown.

The *thundering hedge-hog* is little other than a kind of thundering-barrel, and differs from it only in being thick set with points on the outside. As these points hinder it from rolling, it is moved upon two wheels, by means of a piece of wood that passes through it
trans-

transversely, and serves for the axis or axle-tree of the wheels.

The *torches* consist of old cords, or old match untwisted, and well steeped in tarr. Their use is to illuminate in the night the inside of fosses, or other parts of the fortification of a place attacked.

Powder-sacks

Powder-sacks are bags made of a very coarse, dry cloth, which contain about 4 or 5 pounds of powder, and are so made as to be thrown by hand like the grenado; into these a fuse is introduced, which is tied very tight together with the mouth of the bag, and the whole is then well tarred. These sacks, or bags, set fire to every thing where they fall, and may be used to great advantage in the defence of a place. Great use was made of them in the defence of *Doway*, in 1710.

Powder-sacks are also thrown with the mortar, but then they are made much larger than those thrown by hand, being about 10 inches in diameter, and about 22 or 23 inches long. They are filled with powder as the former, but a bomb of about 6 inches diameter is put in besides, being placed at the bottom of the sack, to prevent the sack from falling on its fuse, which might stifle it, and so prevent its firing the powder in the sack. The fuses, made use of for these sacks, are the same with those used for bombs of 12 inches diameter. This sack is then steeped or soaked in melted pitch and tarr, after which it is put into another sack, or bag, of 11 inches diameter, and about 25 or 26 inches long, which last sack is also steeped or soaked in melted pitch and tarr, the fuse being first carefully fastened to it; lastly, the whole is dipped in water, to prevent it from sticking to the places where they are kept for use.

There are also grenado-balls, bomb-balls, and pebble-balls, of which something must be said.

Grenado-balls are, in some respects, the same with the powder-sacks. They are filled by putting in first one or two pounds of powder at the bottom of the bag, with a grenado; this first layer, or

*Bomb-
balls*

bed, is covered with four grenadoes, and the intervals between them are then filled up with powder, and they are covered with a layer of powder, as the former, upon which four other grenadoes are laid, in the same manner as the first; four different layers of powder and grenadoes are thus made alternately, which ought to fill the bag, leaving only room sufficient to tie it up at the mouth, into which a fuse is inserted, and strongly bound up with it; after which the whole is first dipped into pitch or tarr, and put into another sack, which is first dipped, as the former, into pitch or tarr, and then into water, like the powder-sack, and for the same reason; the fuses of the grenadoes contained in this bag are covered with *etoupelles*, which is a kind of match, consisting of three threads of the finest cotton, well soaked in brandy, and priming or pounded powder, the fire of which instantly communicates itself to all parts, and by this means the grenadoes are more certainly fired than if covered with powder only.

Bomb-balls are also made in the same manner as those of grenadoes; a bomb is first put at the bottom of a bag, and a bed or layer of three bombs, and a bed or layer of powder are laid in alternately. These bombs are six inches diameter, and two or three layers of them are contained in a ball.

Pebble-balls are also made in the same manner as the grenado and bomb-balls, but in these, instead of grenadoes and bombs, pebbles are made use of; and these balls are contrived so as to burst in the air, that the pebbles they are filled with may fall like hail upon the places designed. These balls have nearly the same effect as the *pedrero*, and are even more dangerous to the enemy, because they may be used with much more readiness and speed.

All these sorts of balls are thrown with the mortar.

Besides the different kinds of fireworks already mentioned, two
new

new inventions were used at *Lisle* in the gallant defence of that place made by marshal *Boufflers*. One of these, as related by *M. Quincy* in his account of that famous siege, was a tin-box, covered with a plank, in which were put cloths dipped in tarr, pitch and brimstone. When the box opened, these cloths taking fire, and extending, burnt without resource whomsoever they fell upon, who found it impossible to disengage themselves when these cloths had once fastned on their apparel, without stripping themselves immediately.

The other invention was an earthen pan, or pot, in the shape of a pasty or pye, filled with grenadoes, stuck round with iron spikes, which penetrates whatsoever is in its way.

C H A P. XIV.

Of BRIDGES.

THE bridges which are constructed by an army for passing canals, rivers, &c. being comprehended under the name of *artillery*, we shall here give an account of what concerns them.

These bridges are made with boats, which are placed at small distances from each other, the whole width of the river, parallel to their lengths, and covered with planks, which rest on pieces of wood called *poutrelles*, or joists, firmly fixed to the boats.

There are bridges of boats of many sorts; some are constructed with copper boats, which in artillery are called *pontons*, and which
are

Bridges are carried with an army upon carts or drays, made for that purpose; others are constructed with the common boats found on the rivers which are to be passed.

PL. XV. To construct a bridge of boats, the boats are bound together
Fig. 1, 2. with strong ropes, as is represented in *fig. 1, 2.* of *pl. XV.* A-cross these boats are laid the *poutrelles*, and upon them strong planks of deal, which are firmly nailed on; fir planks are preferred; because that wood is lighter and less brittle than oak.

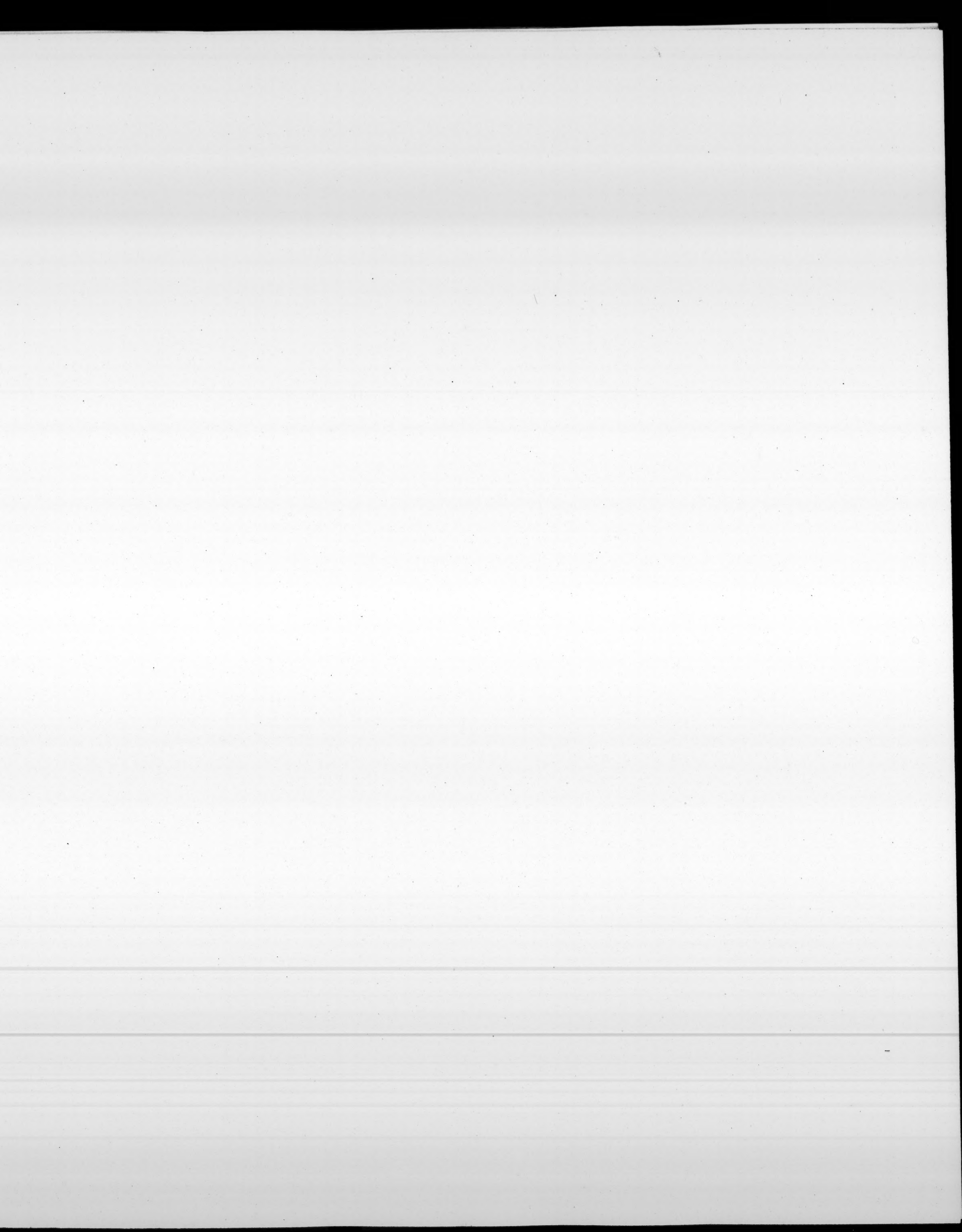
When the river over which the bridge is to be laid is very rapid, anchors are let down from the cord or cable to which all the boats are fastened; these anchors are first cast into the river, and the cord is then drawn as tight as possible, that the boats may be more securely fixt; these cords, or cables, are called in artillery *cinquenelles*, and are generally one inch and an half in diameter, and 100 fathom long.

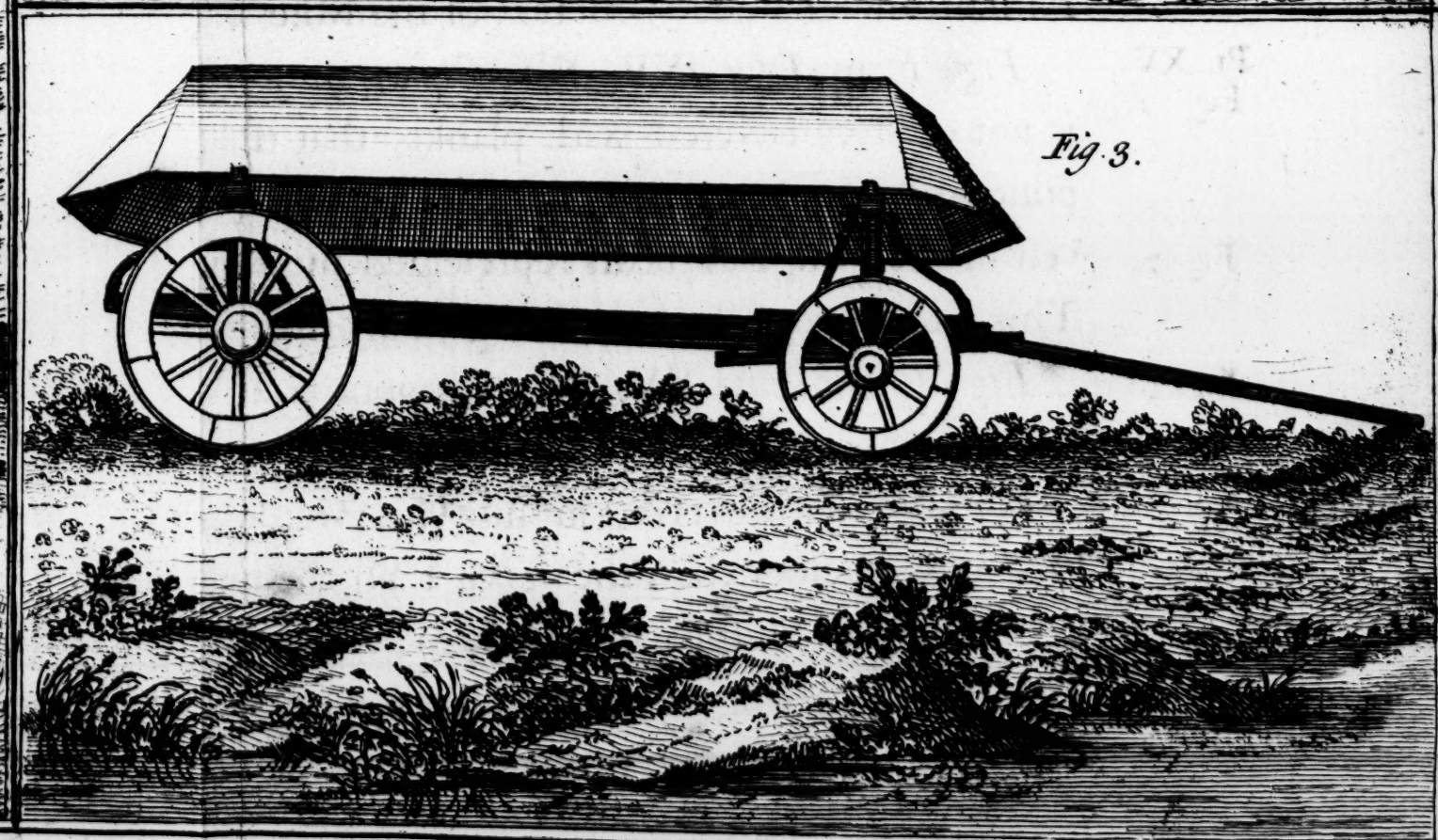
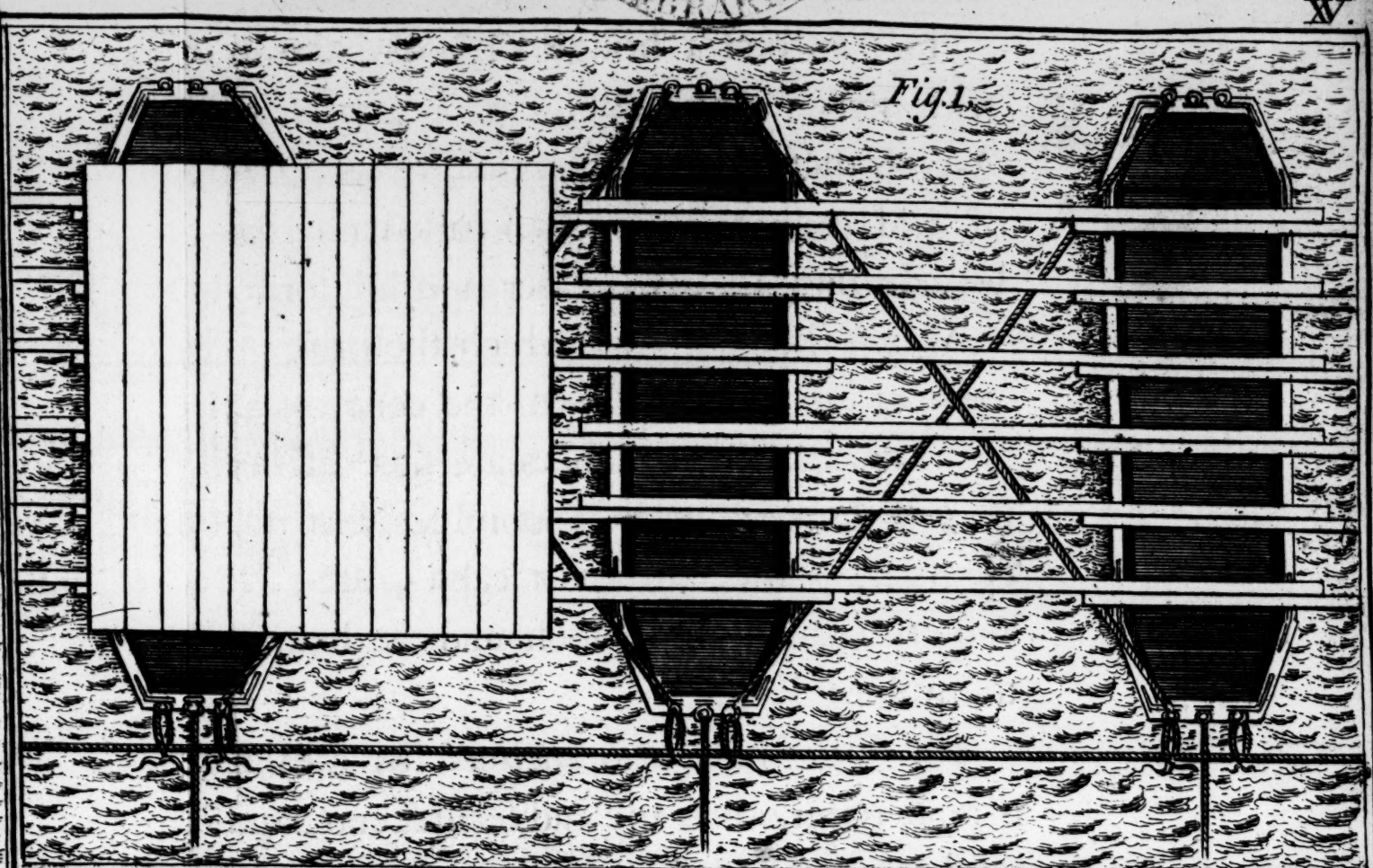
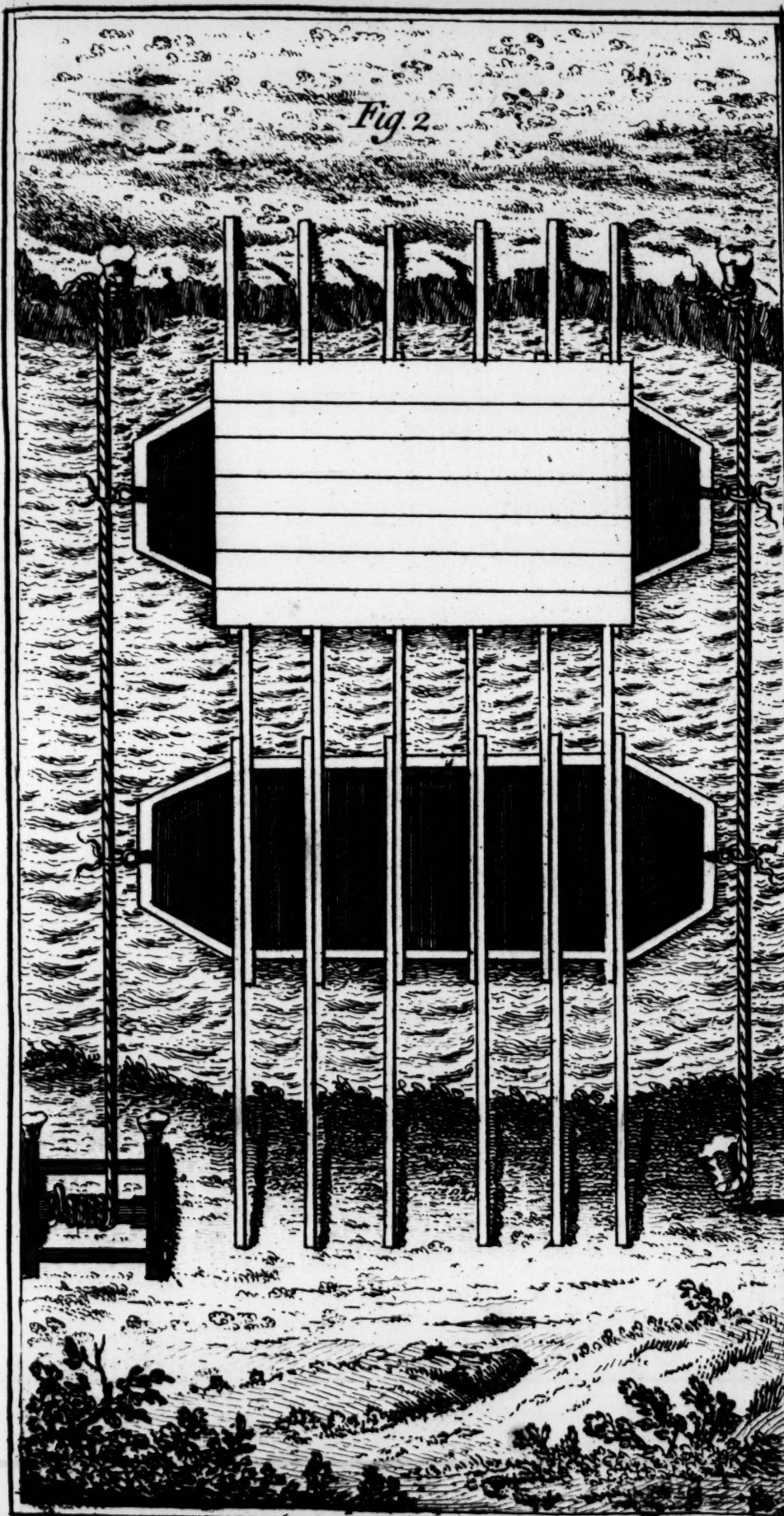
The boats have also anchors, by means of which their situation is rendered more steady and secure, and capable of making a stronger resistance to the tide or motion of the water.

PL. XV. *Fig. 1.* *Fig. 1.* in *Plate XV.* shows part of a bridge of boats, which is not entirely covered with planks, that the arrangement and disposition of the *poutrelles* may appear. The same method is observed in the bridge of boats represented by *fig. 2.* in the same *plate.* This bridge is only for passing small rivers.

Fig. 3. *Fig. 3.* in *Plate XV.* shows a ponton mounted on its carriage or cart.

M. *St Remy* observes, in his *Memoirs*, that the pontons which were in use before the time of M. the marquis *de la Frezelier*, lieutenant-general of the artillery (which post he filled with great distinction) not being capable of transporting twenty-four pounders over large rivers, without danger of sinking, because they lay so
near





near the water's edge, he contrived others longer and higher, which were capable of transporting the heaviest pieces of artillery over any river, without danger of the like inconveniency. The principal dimensions of these boats, according to this author, are as follow :

Their height is 2 feet 9 inches.

Their width 5 feet 6 inches.

Their length 18 feet 6 inches.

The poutrelles, which are of firr, as well as the planks with which they are covered, are 22 feet long, 4 feet and an half wide, and 5 feet thick.

The planks are 14 feet long, 13 inches wide, and 2 inches thick.

The distance between each boat, or ponton, ought to be 9 feet.

Besides the bridges already mentioned, which are most common, there are yet others, called *ponts volants*, or *flying bridges*. These are sometimes boats, joined together by strong ropes, and frequently with chains, upon which a sufficient number of madriers, or planks, are disposed, so as to make a platform proper to receive cannon, and on which they may be fired, either to oppose or favour the passage of a river. An epaulment is also made musket proof, to cover the men who occupy this bridge, and play the cannon.

The *pont volant* is also sometimes a bridge made of one great boat, or several lesser boats, which floating, is drawn cross a river, by means of some machines, or cords, which communicate with the opposite side.

A bridge is also called a *pont volant*, which is made over small rivulets 4 or 5 fathoms wide, and composed of two bridges, laid the one on the other, in such manner as that the upper one may be thrown forward by means of cords and pullies properly disposed in the lower. These bridges can never be large, because the weight of the upper bridge, when it runs out, or is thrown forward,

ward, wou'd, if not very small, break all its fastening to the under bridge, and so the whole machine would be rendered useles; and for this reason they are never used but for passing ditches, fosses, or rivulets not wider than 4 or 5 fathom.

Besides these there is another sort of pont volant, made use of in war on several occasions, called a *raft*, or *float*. This is made of many rafters, or pieces of timber, which together form a kind of floor; these are covered with planks, or strong madriers, and a certain number of empty casks are made fast to the ends of the rafters, the better to support the float, and whatever is placed upon it. These floats are used to transport troops, cannon, &c. over rivers.



XV.

Of the Proof of Powder.

THERE have been different inventions proposed, and put in practice heretofore, for the proof of powder, that is, to ascertain its goodness. But his majesty, by an ordinance of the 18th of *September* 1636, which is still observed, ordered the proof of powder to be made with a small mortar, which should carry a bullet of 60 pounds, to the distance of 50 fathom at least, with only 3 ounces of powder. If the powder threw the bullet to a less distance, it was not received into his majesty's magazines.

PL. VII.
Fig. 5.

Fig. 5. in *Plate 7.* represents this mortar, which is called a *prover*. Its dimensions, according to the ordinance just mentioned, are as follows:

a The diameter of the mouth of the mortar, is 7 inches, and 3 4ths of a line.

b The

- b* The length of the hollow cylinder, or bore, is 8 inches 10 lines.
- c* The diameter of the chamber is 1 inch 10 lines.
- b d* The length, or depth, of the chamber, is 2 inches 5 lines.
- e* The touch-hole, terminating at the bottom of the chamber.
- f* The diameter of the mortar (including the thickness of its metal) at the chace is 8 inches 10 lines.
- g* The diameter of the mortar (the thickness of its metal included) at the chamber is 4 inches 8 lines and an half.
- h* The diameter of the touch-hole is 1 line and an half.
- a i* The thickness of the metal at the ring (not including the moulding or thread) is 10 lines.
- k* The length of the brads (7) femelle of the mortar, which is 16 inches.

(7) We have called a piece of wood which is placed on the transoms at the top of the carriage, to support the breech of cannon, a *femelle*. In the carriage of a mortar for the proving of powder, the part on which the breech of the mortar rests is also called a *femelle*, and is made of the same metal as the mortar, with

which it is also cast. This femelle ought to make an angle of 45 degrees with the mortar, so that if the femelle be placed upon ground of a true level, the line, which is conceived to pass longitudinally through the middle of the bore of the mortar, will make with it an angle of 45 degrees.

CHAP. XVI.

Of the Proof of Cannon.

THE proof of cannon is made to ascertain their being well cast, their having no cavities in their metal, and, in a word, their being fit to resist the effort of their charge of powder. In artillery the name of *chamber*, or *honeycomb*, is given to the flaws or cavities found in the body of the metal of pieces, when they come from the foundery. The discovery of these defects is of great

Of proving Can-
non.

importance, because as the metal is weaker in those parts than in any other, they endanger the bursting of the piece.*

The ordinary method of proving cannon is to fire them several times with very strong charges of powder. In making this proof the piece is laid upon the ground, supported, only in the middle, by a piece of wood about 4 or 5 inches thick; and a convenient place is made choice of for this experiment, to prevent accidents.

When the piece has been fired two or three times, a small quantity of powder is scattered along the bore, and fired in order to clean it; water is then poured in, and pressed toward the breech by a sponge of nearly the same caliber, and the touch-hole being at the same time stopped with the finger, a strict search is made whether the water ouzes out any where, and if it does not, it is certain the piece has no clefts or crevices.

Methods are then taken to discover whether there are any chambers in the inside of the piece; for this purpose an instrument is used, called a *cat*. This *cat* is a piece of iron having one, two, or three claws, or prongs, which are very sharp, and disposed, when there are three of them, in form of a triangle; this piece of iron is fastned to an hampe, or handle.

To examine a piece, the cat is introduced into the bore, or interior part of it, and if there are any cavities therein, it never fails to discover them. There is yet another kind of cat, different from that just mentioned; this last consists of two branches of iron, fixed to the end of a piece of the same metal, each of which has talons or claws of steel. One of these branches has a turning joint, or hinge, governed by a spring, and disposed in such a manner, that when the cat is introduced into the piece, the least cavity relaxes the

* 'Tis not perhaps the weakness of the metal only by so little a dent or cavity, but the cavity extending and communicating with other flaws.

the spring, and by that means is discovered. M. *St Remy* tells us, that the founders, to whom these instruments are not at all pleasing, call the common cat *the Devil*, and that with two spring branches *the spight of the Devil*.

*Proof of
Cannon.*

Wax-lights, and even looking-glasses, are also made use of to examine the inside of cannon. In order to use the looking-glass, or mirrour, it is necessary the sun should shine out bright; the breech of the cannon being then placed towards the sun, and the mirrour overagainst the mouth of the piece, it illuminates the hollow cylinder, or bore, sufficiently to discover the flaws in it, if any such there are.

M. *Dulacq*, in his treatise on the *Mechanism of Artillery*, a work full of curious and useful reflections, observes, that the common method of proving cannon, how high soever they may be charged, concludes nothing with respect to the perfection of the piece, because it does not bring it to the degree of softness, nor give it the shock and agitation which it receives when it is in danger of bursting, neither does it give that dryness to the powder which it would have at such a crisis.

The examination by the cat, the wax-candle, and the mirrour, can only prove the concave superficies of the bore to be smooth, and free from holes or flaws, but none of these experiments can discover the cavities, or hollows, which may happen in the body of the metal. The same may be said of the experiments made with water and smoke. M. *Dulacq* is of opinion, that the best method of proof is to fire the piece about 40 times successively, as quick as possible. It is certain that a piece which stands this proof will obtain a kind of certificate that it is well constructed; but the expence of this method, which is very considerable, deserves some attention.

*Proof of
Cannon.*

The method used by M. *Valliere*, as related by M. *Dulacq*, is first to fire each piece twice charged with its ordinary bullet, and then to fire it twice more, charging it, instead of a bullet, with a cylinder of fat earth, about two feet in length. This cylinder as it were concentrates the action of, or confines the powder in the chamber, or inmost recess of the hollow cylinder of the piece, in such a manner as to make it press on the metal with its utmost force.

This proof is a very good one, and has the advantage of being made with a very small expence of powder.

The same author relates an experiment, which he had seen made at *Lyons*, upon two pieces of cannon which were cast in that city. Each piece was fired above 1500 times successively as fast as possible, their charge each time being one third the weight of the bullet; and after this excessive proof, they were as fit for immediate service, as if they had not been fired at all. “ Their chace was
“ not in the least widened, their mouth continued even and uni-
“ form, and the whole bore or interior cavity appeared perfectly
“ smooth; the founder would have warranted them for as many
“ more discharges at the least; the touch-hole of one of them
“ was scarce at all enlarged, and the other but very little, both of
“ them being in a good state for service.”

This proof, as M. *Dulacq*, remarks, was very fit to ascertain the goodness of pieces cast in a new metal; but should not be made upon any but those first cast, the others made of the same metal need only be proved in the common way.

Errard de Barleduc, in his *Fortification* relates an experiment almost of the same kind, made at *Paris*, by the *Sieur Destroz*, grand master of the artillery of *France*, “ who was seen, says this
“ author, in the time of *Charles* the 9th, to fire the same piece
“ of cannon, with the same powder, two hundred times within the
“ space

“ space of nine hours, without damaging the piece in any respect.” And indeed a great progress had been made in artillery even at that time, by means of the long and bloody wars between *Francis the first*, and the emperor *Charles the fifth*.

C H A P. XVII.



Of the Proof of Mortars.

THE proof of mortars, according to the ordinance of the 7th of *October* 1732, ought to be begun by scraping, with an instrument well tempered, all the places where a flaw is suspected; and if nothing of that kind is discovered, the proof must be proceeded in, by firing them with as much powder as the chamber will contain.

For this purpose the mortar is placed upon the ground, with some part of its trunnions sunk below the surface, and resting on wooden billets, to prevent their being driven in too far; the piece is then fired three times successively, with bombs of a proper caliber, filled with a mixture of earth and saw-dust. The touch-hole is then stopped, and the mortar filled with water, to discover whether there be any crack or flaw through which it can insinuate itself. Afterwards the piece is well washed and scraped, and when no flaws or hollows appear, or any other circumstance to its prejudice, the mortar is received; on the contrary, when any defects are discovered, which might render it less serviceable, its handles are immediately broken off, and the founder can demand nothing for making it.

C H A P.

Of the Artillery necessary for an Army.

IT is not easy to determine the number of cannon which ought to attend an army. A numerous artillery qualifies forces for great enterprizes, and enables them to attack an enemy, and defend themselves, with vast advantage. But, besides that it is very expensive, it is also very troublesome in long and fatiguing marches, and the number of horses it requires very much enhances the expence, by means of the great quantity of forage which they consume.

According to the calculation of our ancient engineers, there ought to be one piece of cannon to every thousand men; so that in an army of 40,000 men, there ought to be 40 pieces of cannon. But the number of cannon ought to be proportioned to the nature of the enterprize an army is intended to undertake, and the difficulties and obstacles it has to surmount. An army has not all its artillery with it at all times, but it sometimes lies canton'd in the neighbouring towns, especially when the army is not near enough to the enemy to expect an attack, or is not intent on coming up with him to give him battle, or, lastly, when the places where the artillery lies are so near as that it may be brought together in a very little time.

We shall now give the particulars of a train of artillery for an army of 50,000 men, pretty near to what M. *St Remy* gives in his *Memoirs*, which will serve to convey some idea of a train necessary for a greater army. That author gives but 50 pieces of cannon to this army, but he supposed it was only to serve in *Flanders*, a place full of fortified towns, from whence cannon and warlike ammunition might easily be brought, in case they should be thought necessary.

A train

ARTILLERY.

III

A train of artillery for an army of 50,000 men, which should be intended to penetrate far into an enemy's country, at a great distance from any fortified places of their own, ought to be much more considerable.

A Table of Things necessary for a Train of Artillery consisting of 50 Pieces of Cannon.

Horses.	Pieces mounted and furnished.	Pounders.	Spare carriages, and sets of furniture.
64	— — 4	— — 24	1 of each,
4	— —	— —	
36	— — 6	— — 12	1
4	— —	— —	
120	— — 20	— — 8	2
8	— —	— —	
80	— — 20	— — 4	2
8	— —	— —	
Total 324	50	48	6

Horses.	Carts.	Bullets.
32	8	of 24lb. 400 at 50 to a cart.
24	6	of 12lb. 600 at 100 to a cart.
52	13	of 8lb. 2000 at 154 to a cart.
28	7	of 4lb. 2000 at 286 to a cart.
Total 136	34	5000

Horses.	Carts.
320	80 Each loaded with 400lb. of powder, 400lb. of bullets, and 300lb. of match, which makes 1100lb. for the load of each cart.*

Horses

|| See p. 113. for the weight allotted to each horse.

* The author having before allotted 300 weight to each horse, which in this ar-

ticle would be 1200lb. to each cart, seems here to allow 100lb. for chests, casks, &c. to contain the powder, bullet and match.

A TREATISE of

Horfes.	Carts.	
16	— - 4	Each loaded with 800 lb. of bullet, and 300 lb. of match.
112	— - 28	Each loaded with 1000 lb. of powder.†
96	— - 24	Each loaded with 250 tools for removing earth, as spades, mattocks, pickaxes, wooden shovels bound with iron, &c.
16	— - 4	For 2000 hedging-bills packed up in barrels.
20	— - 5	For 2000 grenadoes charged and barrell'd.
12	— - 3	For 3 forges compleat.
4	— - 1	Loaded with coals.
Total 596	— - 149	

Horfes.	Waggons.	
15	— - 3	To carry 1000 hatchets with helves.
5	— - 1	To carry the smaller tools.
5	— - 1	To carry 2000 miners tools.
15	— - 3	To carry cordage of several sorts.
5	— - 1	To carry 3000 sacks for earth.
Total 45	— - 9	

Horfes.	(8) Caiffons.	Use
16	— - 4	For the capt. of the artificers 1; for the major or master of the lodge of artillery 1; for the artificers 1; and for the surgeon, major, and the chaplain 1.
8	— - 2	Loaded with cordage for the bridges.
Total 24	— - 6	

Horfes.

† Here 200 lb. is allowed for casks, &c. Or else, as the powder is the most essential article, it is thought proper, by making the load less, to subject the carriage of it to the least inconveniencies possible.

(8) Caiffons are great wooden cafes

covered at the top with a slope or pent, which are carried upon a cart, and serve to contain the various implements belonging to the train, which cannot be carried in the common waggons and carts, also the ammunition-bread.

Horfes.	Carriages.	Pontons.
120	20	For 20 copper boats, or pontons, mounted.
12	2	Spare drays, or carriages.
Total 132	— - 22	

Total Amount of all the Apparatus for a Train of 50 Pieces of Cannon.

	Horfes.	Carts.	Wag- gons.	Caiffons.	Spare Carriages.	Pontons on Carriages.
For Cannon	324	34	- 9	— - 4	— - 6	— - 20
Carts	732	149	—	— - 2		
Waggons	45					
Caiffons	24				Drays 2	
Pontons	132					
	1257	183	- 9	— - 6	— - 8	— - 20

It must be remarked in this table, that the load of each cart drawn by 4 horfes is estimated at about 1200 lb. weight. It has been proved, that the force of a draught-horse may be estimated, at a medium, to be equal to about 300 lb. weight ⁽⁹⁾, the result of which is, that 4 horfes can draw a weight of 1200 lb. There are nevertheless some ways, and some kinds of foil, as mountains, &c.

Q

where

(9) In the Memoirs of the Royal Academy of Sciences for the year 1699, it is shewn, that the force of a man, exerted in drawing a weight in an horizontal direction, walking with his body something inclined forwards, is equal to no

more than 27 lb. ; and that the force of an horse, drawing a load, is equal to that of seven men, that is, to seven times 27 lb. or 189 pounds ; but this is without the assistance of any carriage, or mechanics. An horse harnessed to a cart is able

where a horse cannot draw 300 lb. weight; but these are extraordinary cases, the inconveniencies of which are remedied by relays of horses, which are generally found among trains of artillery, or by horses, or other beasts of draught, taken up on the spot.

Our 24 pounder is known to weigh 5400 lb. weight; if this number be divided by 300, the number 18 will result for the quotient, which is the number of horses necessary to draw this piece of ordnance. They may however be very well reduced to 16, as is done in the preceding table, because the strength of all the horses being as it were united, is capable of an effort something greater than could be made by their strength, if exerted separately.

In the same manner the number of horses necessary to draw any other pieces, of which the weight is known, may be found. The weight of each piece of ordnance is generally marked upon it, all our founders being obliged to mark the weight, not only upon cannons, but even on mortars and pedreros, by the ordinance of the 7th of *October* 1732.

Under the article of cannon we have taken notice of the weight of the principal pieces, and we shall here add the weight of mortars, which was omitted under that head.

able to draw a much greater weight, especially on a smooth, plain, or level road, lying in an horizontal direction, because no force is then required more than sufficient to overcome the friction of the wheels; but upon uneven ground an horse cannot draw the same load, because, besides the friction, he has the

resistance made by the irregularities of the ground to surmount, and also some part of the weight the cart is loaded with to support. It is only in common ways, and those tolerably even, that the force of an horse, harnessed to a cart for the drawing of a certain weight, is estimated, at a medium, at 300 lb.

SECT. II. *Of the Weight of Mortars.*

ACCORDING to *St Remy*, the mortars which have concave chambers, that hold 18 pounds of powder, weigh about 5000 lb. those the chambers of which hold 12 lb. of powder, 2500; and those whose chambers contain 8 lb. weigh about 2000. According to the ordinance of *October 7, 1732*, the mortar of 12 inches diameter, with a cylindrical chamber containing 5 pounds and an half of powder, ought to weigh 1450 pounds; that of 8 inches, 3 lines diameter, with a cylindrical chamber, containing one pound and three quarters of powder, ought to weigh 500 lb. that of 12 inches diameter, having a chamber in shape of a pear, containing 12 lb. of powder, 2300 lb. and, lastly, that of 12 inches diameter with the pear-shaped chamber, containing 5 lb. and an half of powder, ought to weigh 1700 lb.

To the tables already given we shall yet add a plan of a train consisting of 1000 horses, as given by *M. de Quincy*, author of the *Military History of Lewis XIV.* which will serve to give a more compleat idea of all the things necessary in a train of artillery, with regard to the number of horses employed in it. This train is divided into brigades, that is, into the different corps which a train of artillery is divided into, in order to march.

Plan of a Train of Artillery, consisting of one thousand Horses.

First Brigade.

Teams.

Horses.

- 1 For one waggon with 300 tools, one third mattocks, one third spades, and one third hedging-bills

4

Q²

Four

Teams.

Horses.

1	Brought over	4
12	For 4 pieces of cannon, 24 pounders (10) of the new invention, mounted and furnished	48
2	For 1 spare carriage with its <i>chevre</i> , (11) or triangle, and 2 sets of furniture	8
3	For 3 waggons of neat powder, each loaded with 1200 weight	12
8	For 8 caissons of bullet, each containing 50 bullets, 10 cartouches, and 6 packs of match	32
5	For 5 waggons, each loaded with 3 casks of powder, 3 barrels of shot, and 1 of flints for the firelocks, containing 900	20
2	For 2 waggons for the officers of the brigade	8
33		132

Second Brigade.

Teams.

Horses.

1	For 1 waggon of tools, as in the first brigade	4
16	For eight 8 pounders with their furniture	64
		For

(10) These are pieces with spherical chambers, which M. de Quincy thinks very useful in a field-equipage, because they are lighter than others. A 24 pounder of this make weighs little more than 3000 lb. ----- See the inconveniencies for which these pieces have been laid aside in page 18.

(11) The *Chevre*, or triangle, is an instrument with three feet, being three poles, joined together at the top, which are disposed triangularly, and support each other. Two of these pieces of wood form a kind of *scale*, and terminate in a point above the machine. At about one third of the height of the machine, or at three or four feet from the bottom, is

a capstern, to which a rope is fastened, that runs over a pulley placed at the top of the *chevre*; with this rope any weight is raised, by turning the capstern, and so winding the cord, or rope, round it. The pulley at the top of the *chevre* is sometimes mouffled, that is, composed of a complication of pulleys, co-operating together, by which the effect of the machine is much increased, that is, it's rendered capable of raising a greater weight with the same force. The *chevre* is made use of to raise cannon and mortars, in order to place them on their carriages, and on all other occasions in the working of artillery.

ARTILLERY.

117

Teams.	Horses.
17 Brought over	68
1½ For 1 spare carriage, and 2 sets of furniture, 1 team and an half, making	6
4 For 4 waggons of neat powder, each loaded with 1200 weight	16
6 For 6 caissons of bullet, each containing 130, 20 car- touches, and 6 packs of match	24
5 For 5 waggons loaded as in the first brigade	20
2 For 2 waggons for the officers	8
35½	142

Third Brigade.

Teams.	Horses.
1 For 1 waggon of tools	4
10 For ten 4 pounders mounted, with their furniture	40
1 For 1 spare carriage, and 2 sets of furniture	4
2 For 2 waggons of neat powder	8
3 For 3 caissons of bullets, each containing 300, 20 car- touches, and 6 packs of match	12
5 For 5 waggons loaded as in the former brigade	20
2 For 2 waggons for the officers	8
24	96

Fourth Brigade.

Teams.	Horses.
1 For 1 waggon of tools	4
10 For ten 4 pounders mounted, with their furniture	40
1 For 1 spare carriage, and 2 sets of furniture	4
2 For 2 waggons of neat powder	8
	For

A TREATISE of

Teams.	Horses.
14 Brought over	56
3 For 3 caissons of bullets, with cartouches and match, as before	12
5 For 5 waggons loaded as in the first brigade	20
2 For 2 waggons for the officers	8
24	96

Fifth Brigade.

Teams.	Horses.
1 For 1 waggon of tools	4
10 For ten 4 pounders mounted, with their furniture	40
1 For 1 spare carriage	4
2 For 2 waggons of neat powder	8
3 For 3 caissons, containing each 300 bullets, 20 cartouches, and 6 packs of match	12
5 For 5 waggons loaded as before	20
2 For 2 waggons for the officers	8
24	96

Sixth Brigade.

Teams.	Horses.
1 For 1 waggon of tools	4
10 For ten 4 pounders mounted, with their furniture	40
1 For 1 spare carriage	4
2 For 2 waggons of neat powder	8
3 For 3 waggons of 300 bullets each, 20 cartouches, and 4 packs of match	12
5 For 5 waggons loaded as before	20
2 For 2 waggons for the officers	8
24	96
	Se-

ARTILLERY.

119

Seventh Brigade.

Teams.	Horses.
1 For one waggon of tools	4
10 For ten 4 pounders mounted, with their furniture	40
1 For 1 spare carriage with its furniture	4
2 For 2 waggons of neat powder	8
3 For 3 caissons of bullets, containing each 300 bullets, 20 cartouches, and 6 packs of match	12
5 For 5 waggons loaded as before	20
2 For 2 waggons for the officers	8
24	96

Besides these seven brigades, there must be yet more teams, to draw the tools, and other things necessary in a train of artillery, *viz.*

Teams.	Horses.
3 For 3 waggons of tools	12
4 For 4 waggons of grenadoes	16
15 For 15 waggons loaded with powder, ball, and flints for the firelocks	60
1 For 1 waggon of hogs-grease	4
1 For 1 waggon of earth-sacks, and cordage	4
1 For 1 caisson loaded with 4000 earth-sacks, 10 pair of traces, 6 double and 4 single, and 1 barrel containing 1000 flints for the firelocks	4
1 For 1 caisson loaded with 300 hatchets	4
1 For 1 caisson loaded with 600 bills	4
2 For 2 caissons of miners tools	8
2 For 2 forges complete	8
1 For 1 waggon loaded with 1200 weight of iron	4
1 For 1 waggon of wood for remounting	4
33	132

A TREATISE of

For the Equipage of the Officers, &c. belonging to a Train of Artillery.

Teams.	Horses.
6 Belonging to the first commandant	24
2 To the second	8
2 To the third	8
1 To the major	4
1 For the caisson of bread	4
1 For the commandant of the battalion, employed as provincial commissary	4
1 For the comptroller	4
1 For a waggon for the commissary of the park, or the place where the artillery is brought together	4
1 For the chaplain and surgeon	4
1 For the captain-general of the waggons	4
17	68

The total number of horses employed in the brigades, &c. above, amounts to 954 ; so that 46, or 11 teams and an half, are still remaining, which serve to draw what in artillery is called the *menus achapts*, or small things ; as flamboys, candles, cordage and pack-thread, wire, padlocks, nails, steel, glue, files, lanterns light and dark, tin measures to measure the powder, tunnels, paper, pen-knives, ink, sealing-wax, &c. and also the tools of the artificers belonging to the artillery.

C H A P.

Of the March of a Train of Artillery.

THE artillery is divided into brigades, as appears by the preceding account ; and a brigade generally consists of 8 or 10 pieces of cannon, with all the necessaries and furniture belonging to them. Officers are appointed to conduct each brigade, and the whole, according to M. Quincy, marches in the following order.

“ That part of the army, called the *Royal Artillery* battalion,
“ marches at the head of the train ; as many detachments, consist-
“ ing of 15 men each, commanded by a lieutenant, are drawn out
“ from this battalion, as there are brigades, for their escort, or
“ guard. When the artillery marches with the army, the military
“ chest is placed at the head of the train.”

There are also a number of pioneers, proportioned to the repairs the ways are supposed to require, who march after the first battalion of royal artillery, and are under the direction of a skilful officer, in capacity of their commander, who is to conduct them in such a manner as may be most convenient on the march.

These are followed by a waggon loaded with tools of all sorts, and a light brigade, that is, a brigade composed of pieces of the smallest caliber. Then come the equipages of the first commandant, of the second commandant (if there is one) and of the major of the battalion.

After these another light brigade, with the equipages of the officers of the battalion ; and the equipages of the rest of the officers march at the head of the brigades to which they respectively belong.

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A TREATISE of

The other brigades follow in such an order as that the heaviest, or that which is composed of the largest cannon, may march in the centre ; so that if there are six light brigades, there may be three before and three behind this heavy brigade, which is sometimes called the *park brigade*.

All the brigades, except the park brigade, change places among themselves, that is, each one is alternately at the head and in the rear, that the fatigue of each post may be equally divided.

The rear-guard of the train consists of 50 men, draughted out of the royal artillery, and commanded by a captain.

Each brigade has a captain of the waggons, and two conductors, with a certain number of artificers, to repair such accidents as may happen in the march.

The provincial commissaries march at the heads of their brigades, and see that the officers appointed to conduct them preserve the order of the march, and do not quit their post till the brigade arrives at the place intended.

C H A P. XX.

Of the Artillery-Park.

WHEN the artillery is arrived at the place appointed for it by the general of the army, it is there lodged, and the space which it occupies is called *the park of the artillery* ; the ammunition is ranged in the same order as the battalions of the royal artillery, appointed for its defence and service.

The figure of the park of artillery is generally that of a rectangular

angular parallelogram, if the situation of the ground does not make another form necessary.

The commissary of the park, according to M. Quincy, marks with pickets the spot on which the first waggon of each brigade is to be placed, and posts the rest of that brigade on the same line, separating one brigade from another, so as that when the train marches again, it may be done without confusion.

Some commandants, according to the same author, place the pieces of the first line first, and next these, the waggons containing the ammunition intended for the service of these pieces; and afterwards place the pieces of the second line in the same manner, forming the first line with one half of the artillery, and the second line with the other. These gentlemen are of opinion that the park may be divided in this order with less confusion than in the preceding; the others think that, by placing all the cannon in the first rank, and the proper ammunition behind each brigade, the park is raised, *i. e.* the artillery renews its march, with as much ease, and with a better effect.

The arrangement of the artillery however depends upon the will of the commandant, except that he ought always to observe the following particulars, *viz.* that the pieces of cannon and the carts ought to be two paces distant from each other, the brigades 5 paces, and the lines 40 paces: When there are pontons in the train, they form the last rank, and are 40 paces distant from the preceding.

The park-guard consists of 50 men, draughted from the battalions of the royal artillery, who are posted overagainst the park at the distance of 40 or 50 paces from the front; from these also the centinels of the park are draughted, two of which are posted at each rank, sword in hand, and without fire-arms.

The battalions of the royal artillery are placed at the right and left of the park, and the carriage-horses at about 300 paces distance, on the right or left, in a commodious place, where they may be out of danger.

When the army is encamp'd in form, in a field or open place, the artillery is placed overagainst the centre of the first line formed by the troops, at the distance of 3 or 400 paces from the front of this line, if the ground will permit; otherwise it is placed at the distance of 2 or 300 paces behind the centre of the second line.

About 100 paces before the park, three advanced pieces of cannon are planted, charged, and ready to be fired, which are called *alarm-pieces*, because they are used to call in, on a sudden, the troops which are foraging, when there is a necessity of so doing, and to give the alarm for the whole army to put itself under arms, or for any other purpose to which the general thinks proper to appoint them. A cannoneer is always posted near these pieces, with a match ready lighted.

C H A P. XXI.

Of the Ammunition necessary for forming the Attack or Siege of a fortified Place.

NOTHING can be laid down under this head with great exactness, because it may happen that a place of but small extent, as *Philipsburgh*, shall be capable, by its situation, of making a vigorous defence, and require more artillery to attack it than a larger place. The number of attacks proposed

to

to be made, and the obstacles which are foreseen to be necessary to be surmounted, ought to determine the number of artillery proper for an army to make use of, in order to succeed in its enterprize.

Example may serve us here instead of precept. The following account, from a very able engineer, may serve to give an idea of the principal things necessary for forming a siege. This estimate, or list, was drawn up for forming the siege of one of the most considerable towns in *Flanders*.

*List of the Ammunition and Provisions collected together
for forming the Siege of *****.*

Ammunition-bread.

SUPposing the army to consist of 32,000 foot and 18,000 horse, two regiments of bombardiers, fuzileers, general officers, miners, cannoneers, persons belonging to the hospitals, and 10,000 peasants. Less than 90,000 rations of bread, per day, will not suffice for the first 10 days; and for the 30 days, which it may be supposed the place will hold out, before the garrison evacuates the town, 80,000 per day; which, reckoning 180 rations to the septier of *Paris*, makes in all for 40 days about *Septiers* 18,350

Forage.

At the rate of 18,000 rations per day, supposing the horse without the camp and lines, the ration estimated at 10 lb. of hay, 6 lb. of straw, and 3 pecks of oats, the whole for 40 days makes

Rations 72,000

Pow-

A TREATISE of

Powder.

For 40,000 charges, for 24 pounders, each charge estimated at 12 lb. of powder	lb. 480,000
For 16,000 charges for 16, 12, 8, and 4 pounders, each charge estimated at 6 lb. one with another	96,000
For firing 9000 bombs during the siege, after the rate of 300 per day for 30 days, which it is supposed to last, at 16 lb. of powder each fire, including the charge of the mortar and the fuse	144,000
For 40,000 grenadoes, at the rate of 2000 per day, during 20 days guard of the trenches, the charge of each estimated at 4 oz. and an half	11250
For the consumption of the musquetry, in guarding the trenches for 30 days, estimated at 30,000 discharges per day, 24 fires being allowed to 1 lb. of powder, making in the whole	37,500
The common distribution before opening the trenches	12,000
For waste	12,000
Total weight of powder	lb. 792,750

Besides this quantity of powder, there ought to be 150,000 lb. in readiness, and at hand to be made use of, if necessary, together with a proportionable quantity of bullet.

Artillery.

Great cannon, of ⁽¹²⁾ 33 and 24 pounders, with their carriages, fore-carriages, and furniture	50
Spare carriages — — — — —	25
16 pounders — — — — —	10
12 pounders with their carriages, and furniture	10
8 pounders ditto — — — — —	10
(12) Pieces of this caliber are not now cast.	4 poun-

ARTILLERY.

127

4 pounders ditto	—	—	—	—	20
Spare carriages for the 16 pounders	—	—	—	—	6
for the 12 pounders	—	—	—	—	4
for the 4 pounders	—	—	—	—	6
And furniture for the same pieces in proportion.					
Mortars from <i>Tournay</i>	—	—	—	—	24
Ditto from <i>Doway</i>	—	—	—	—	16

Bullets.

Of 33 lb.	[not used of late]	—	—	12,000
Of 24 lb.	—	—	—	19,000

Musket-ball.

With respect to the quantity of powder allotted to the musketry, computed at 24 balls to the pound, waste included — — — — — 55,000

Match.

The consumption of match, estimated on the supposition of 6,000 lengths, being perpetually burning together during 30 days siege, each length of 5 feet, burning 12 hours, is, for the whole 30 days, 36,000 lengths; which reduced to weight, at the rate of 5 lengths to the pound, amounts to 72,000 lb. and allowing, for waste, 10,000 lb. the whole amounts to — — — — — lb. 82,000

Wood.

60 platforms, each containing 700 feet of joists, at 2d per foot.
 50,000 feet of oaken plank at the same price.
 100,000 feet of deal plank, at 1d. $\frac{1}{2}$ per foot.
 400,000 feet of joists, in pieces, at the same price.

Work.

A TREATISE of

— *Workmen to be employed at the siege.*

One hundred carpenters.

Twelve sawyers.

Twelve smiths.



Tools.

Hatchets	—	—	—	—	—	—	—	800
Pickaxes, &c.								

This list containing only the principal ammunition for this siege, we shall add a list of *all* the apparatus which were provided for undertaking the siege of *Turin*, in 1706, in order to convey a more exact and comprehensive idea of the quantity of each particular necessary in these sort of undertakings. This siege was one of the most considerable of the war which broke out in 1701; and, although it was not attended with the success which might reasonably have been expected *, no one thing was wanting, as we are informed by the military historian of *Lewis the Great*, of all that was necessary to render it effectual. As this place by its situation, which is one of the most advantageous; by its fortifications, which were laboured with great assiduity and care, under the direction of the duke of *Savoy*; by its numerous garrison, consisting of chosen troops, and commanded by a general of deserved reputation; by its largeness, and the number of its inhabitants, who had all resolved to sacrifice every thing for the preservation of their prince's capital city and residence; and, lastly, by the great quantity of all sorts of ammunition and provisions, particularly powder, which the duke of *Savoy* had taken care to lay in: as this place, I say, may be re-

* A late author tells us that madam de *Maintenon* caused the siege of this place to be prolonged till it was relieved by *P. Eugene*, which was in order to prevail on the king to marry her, by employing a priest to urge the ill success of his majesty's arms at *Turin*, as a judgment on his violated promises to her.

regarded on all these accounts as one of the most important which could be attacked, the particulars of the warlike stores which were carried to the siege of it may serve as a model, or at least give some idea of what things are necessary in order to undertake the siege of the largest and most regularly fortified towns.

List of Ammunition carried to the Siege of Turin, in the Year 1706, distinguishing what part of it was consumed before that Place.

<i>Ammunition carried to the Siege of Turin.</i>						<i>Ammunition consumed.</i>
<i>Cannon</i>						
24 pounders	—	—	—		104	
16	—	—	—	—	6	
12	—	—	—	—	17	
8	—	—	—	—	10	
4	of which 13 were long, 4 of the new invention, and 6 carried on the backs of mules				35	
<i>Carriages</i>						
Of 24 pounders	—	—	—		153	45
16	—	—	—	—	11	5
12	—	—	—	—	35	2
8	—	—	—	—	10	
4	For long pieces		—	—	13	} 5
	For those of the new invention		—		4	
	For those carried on mules		—	—	4	
Avant trains, or limbers			—		180	7
Waggons for the bodies of the cannon					90	
Waggons railed	—	—	—		110	
Waggons for bullets		—	—		30	
Carts	—	—	—	—	30	
Triangles with their pullies			—	—	8	
Sling carriages for timber	—		—		1	
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A TREATISE of

Ammunition carried to the Siege of Turin.

Ammunition
consumed.

<i>Cannon furniture</i>							
Sets for 24 pounders	—	—	—	—	126	—	40
for 16	—	—	—	—	10	—	4
12	—	—	—	—	20	—	6
8	—	—	—	—	12	—	3
4	—	—	—	—	40	—	8
Worms to draw charges, &c.	—	—	—	—	20	—	8
<i>Bullets</i>							
Of 24	—	—	—	—	89,623	69,237	
16	—	—	—	—	26,859	15,900	
12	—	—	—	—	21,210	21,000	
8	—	—	—	—	3,800	3,500	
4	—	—	—	—	8,400	4,000	
Cartouches for the troops	—	—	—	—	278,000	106,000	
<i>Cartouches made of tin</i>							
For 16 pounders	—	—	—	—	150	—	150
12	—	—	—	—	40	—	40
8	—	—	—	—	50	—	50
4	—	—	—	—	60	—	60
<i>Mortars.</i>							
Of 12 inches diameter	—	—	—	—	39		
9	—	—	—	—	7		
6	—	—	—	—	13		
<i>Carriages</i>							
For mortars of 12 inches, of which 10 were of cast iron	—	—	—	—	43	—	10
For mortars of 9 inches	—	—	—	—	12	—	5
of 6	—	—	—	—	14	—	4
<i>Bombs</i>							
Of 12 inches diameter	—	—	—	—	13,960	13,849	
9	—	—	—	—	5,549	3,782	
6	—	—	—	—	5,646	3,314	
Fuses for bombs of 12 inches	—	—	—	—	20,000	13,849	
9	—	—	—	—	10,000	3,782	
6	—	—	—	—	8,000	3,314	

ARTILLERY.

115

Ammunition carried to the Siege of Turin.

Ammunition consumed.

Grenadoes charged	—	—	—	25,541	23,200
Grenadoes not charged	—	—	—	21,185	4,500
Fuses for grenadoes not charged	—	—	—	30,000	4,500
Bales of wool	—	—	—	224	224
Sacks for earth	—	—	—	174,160	142,260
Flints for the firelocks	—	—	—	415,200	90,000
Pioneers tools	—	—	—	56,375	54,742
Helves or handles for tools	—	—	—	24,580	24,580
Hatchets	—	—	—	2,685	1,892
Hedging bills, or pruning knives	—	—	—	5,230	1,209
<i>Miners tools</i>					
Pickaxes	—	—	—	1,000	800
Sledges	—	—	—	150	100
Crows	—	—	—	102	80
Cloven-footed crows	—	—	—	30	30
Borers	—	—	—	300	200
Chissels for boring	—	—	—	32	12
Gads	—	—	—	99	99
Trowels, or short spades	—	—	—	6	6
Carpenters and wheel-wrights tools of every fort	—	—	—	316	216
Smiths tools of every fort	—	—	—	55	55
Joiners tools of every fort	—	—	—	43	30
<i>Cordage</i>					
Double coils of rope	—	—	—	86	30
Ropes for the pullies	—	—	—	20	12
Single coils	—	—	—	100	50
Pairs of traces for cannon	—	—	—	200	100
Pairs of common traces	—	—	—	220	120
Packing cordage	—	—	—	bales 42	30
Small cordage	—	—	—	lb. 2,500	2,200
Packthread	—	—	—	lb. 500	500
<i>Wood for remounting</i>					
Beams	—	—	—	200	
Shafts	—	—	—	50	

A TREATISE of

*Ammunition carried to the Siege of Turin.**Ammunition
consumed.*

Axle-trees	-	-	-	-	100	
Tallies	-	-	-	-	500	
Spokes	-	-	-	-	800	
Wheels for 24 pounders, bound with iron					20	20
Wheels for 24 pounders, unbound					10	10
Wheels for the carts which carry the bodies of cannon		-		-	30	30
Wheels for the carriage of the powder and bullets		-		-	10	10
Wheels for the fore-carriages				-	10	8
Lever	-		-	-	100	100
Aiming-wedges		-		-	800	500
Chapiteaux, or aprons			-	-	300	300
Madriers for the platforms				-	100	100
Deal planks		-		-	500	500
<i>Fireworks</i>						
Brimstone		-		-	lb. 2000	1,000
Saltpetre	-			-	lb. 2500	2,000
Fire-balls		-		-	150	150
Tarred fascines		-		-	100	100
Oil of turpentine		-		-	lb. 50	50
Pitch and tar		-		-	lb. 200	200
Chest of bombardiers utensils				-	1	1
Wax for topping the fuses of bombs					lb. 300	300
Bees-wax	-			-	lb. 100	100
Barrels of priming powder				-	2	2
Chest of composition for the fuse				-	1	1
Iron in plates square and round					lb. 5,000	3,000
Boxes of iron of every sort				-	lb. 20,000	12,000
Old nails of all sorts		-		-	10,000	10,000
Steel	-	-		-	lb. 400	300
Wheel nails	-		-	-	10,000	6,000
Nails for the cheeks of carriages				-	15,000	10,000
Nails of all sorts		-		-	60,000	30,000
Pickard nails		-		-	50,000	20,000

ARTILLERY.

117.

Ammunition carried to the Siege of Turin.

*Ammunition
consumed.*

Coopers nails	-	-	-	10,000	8,000
Nails for the sponge or maulkin	-	-	-	12,000	9,000
Brass nails for the ladles	-	-	-	lb. 200	200 lb.
<i>Tin Measures.</i>					
Of 10 pounds	-	-	-	200	200
Of 8	-	-	-	100	100
Of 6	-	-	-	80	80
Of 4	-	-	-	150	150
Of 3	-	-	-	100	100
Of 2	-	-	-	150	150
Of 1	-	-	-	80	80
Of $\frac{1}{2}$ a pound	-	-	-	100	100
Of 2 oz.	-	-	-	50	50
Tin tunnels	-	-	-	50	50
Balance beams with their scales	-	-	-	1	1
Brass weights of 25 lb.	-	-	-	4	
Of 10 pounds	-	-	-	1	
Of 5 pounds	-	-	-	1	
Bellows	-	-	-	pairs 8	
Anvils	-	-	-	8	
Plate iron	-	-	-	lb. 288	288
Plates of mill'd copper for pontons	-	-	-	9	9
Sheepskins for maulkins	-	-	-	210	210
Wicker panniers	-	-	-	200	200
Wicker hods	-	-	-	300	300
Bullet-facks	-	-	-	100	100
<i>Small furniture.</i>					
Bougies, or wax-candles	-	-	-	lb. 1,100	1,100
Candles	-	-	-	lb. 800	800
Flamboys	-	-	-	144	144
Hogs greafe	-	-	-	lb. 3,100	3,100
Torches	-	-	-	lb. 400	400
18 chests of lanterns	-	-	-	570	570
Files, triangular, square, flat and round	-	-	-	116	116

A TREATISE of

*Ammunition carried to the Siege of Turin.**Ammunition
consumed.*

Small files	-	-	36	36
Vices	-	-	4	4
Iron wire	-	-	lb. 100	100
Brass wire	-	-	lb. 74	74
Hand-saws	-	-	130	130
Great saws	-	-	3	3
Rasps	-	-	36	36
Sheets of tin	-	-	1,200	1,200
Jacks	-	-	5	5
Painted mule-cloths	-	-	100	100
Painted cloths for powder	-	-	39	39
Coverings of waxed cloth	-	-	300	300
Brass pulleys	-	-	32	12
Reams of fine paper for accounts	-	-	5	5
Reams of cartridge paper	-	-	52	52
Reams of paper for letters	-	-	6	6
Pens	-	-	200	200
Penknives	-	-	12	12
Augers	-	-	50	50
Needles	-	-	30	30
Sewing thread	-	-	lb. 20	20
Oil of olive for the miners	-	-	lb. 80	80
Cotton	-	-	lb. 180	20
Lamps	-	-	60	60
Powder	-	-	lb. 1,411,200	1176760
Shot	-	-	lb. 150,900	130,507
Match	-	-	lb. 41,800	18,794

*End of Treatise I.*

Ammunition
continued.

Ammunition carried to the Siege of Tunis

Small files	30
Vices	4
Iron wire	100
Brass wire	10
Hand-saws	150
Great saws	8
Raps	10
Sheets of tin	100

Jacks
Printed mule-cloths
Printed cloths for powder
Coverings of waxed cloth
Blue pulleys

Reams of fine paper for accounts

In the Press, and speedily will be published,

**M. LE BLOND'S two other Treatises Of THE ATTACK and Of THE
DEFENCE of fortified Places, with an Universal MILITARY
DICTIONARY, and several additional Plates.**

Agers

Needles

Sewing thread

Oil of olive for the miners

Cotton

Lamps

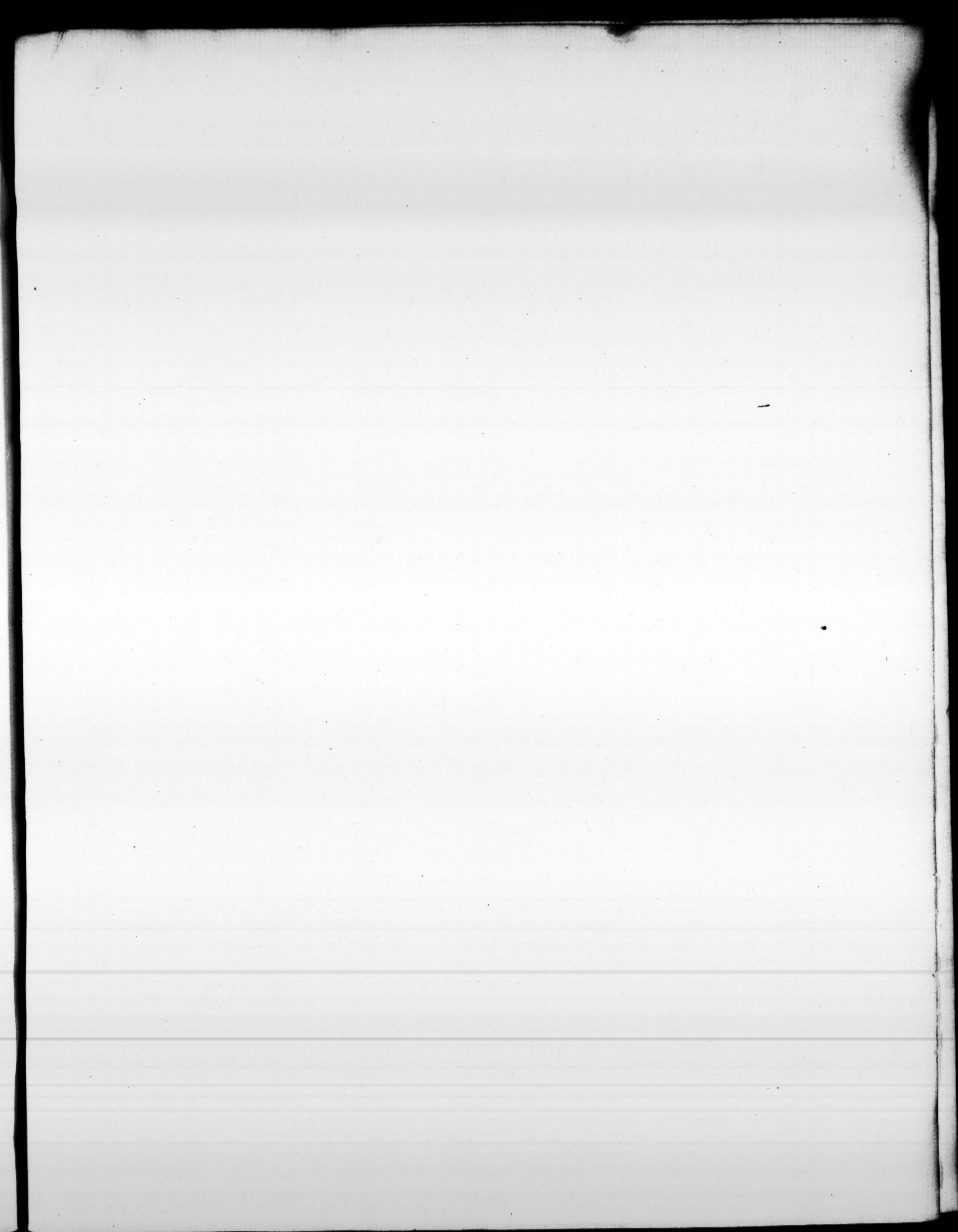
Powder

Shot

Match

End of Treatise

In the First, and possibly with the
M. L. B. and the other two, the
Difference of the two is
In the second, and possibly with the



W